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EPA WORK ASSIGNMENT NUMBER: 136-3LP5
CONTRACT NUMBER 68-01-7250
EBASCO SERVICES INCORPORATED

FINAL WORK PLAN
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
FOCUSED FEASIBILITY STUDY

GREENWOOD CHEMICAL SITE
ALBEMARLE COUNTY, VIRGINIA

OCTOBER 1988

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NOTICE

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1.0 INTRODUCTION

Ebasco Services, Incorporated (Ebasco) is submitting this Work Plan for performance of a Remedial Investigation/-Feasibility Study (RI/FS) and Focused Feasibility Study (FFS) for the Greenwood Chemical Superfund Site located in Albemarle County, Virginia, to the United States Environmental Protection Agency (EPA). This Work Plan was prepared in response to EPA Work Assignment Number 136-3LP5 under Contract Number 68-01-7250. Preparation of this Work Plan was accomplished pursuant to the Work Plan Memorandum dated May 19, 1987 and subsequent Work Assignment Amendments.

1.1 PROJECT APPROACH AND OBJECTIVES

Since the beginning of EPA involvement with the Greenwood Chemical Superfund Site in the spring of 1985, EPA has completed a significant amount of environmental site characterization and waste treatment/removal activities at the site. A consequence of these previous actions is that a substantial environmental database has been established for the site. This database has facilitated the development of a focused and cost-effective plan for addressing the remaining potential environmental concerns at the site.

Complex hazardous waste sites are often divided into smaller, more manageable components or Operable Units (OU's) which can be addressed in a prioritized, stand-alone manner.

For the purposes of further study and remedial actions, the remaining areas of potential environmental concern at the Greenwood Chemical Site will be grouped into the following four OU's.

OU-1:	Remaining Containers, Sludge and Lagoon Soils
OU-2:	Groundwater and Surface Water
OU-3:	Other Soil
OU-4:	Underground Structures

For the Greenwood Chemical Site, the first priority will be to address OU1. Specific components of this OU include: the drums and containers in the buildings for which Greenwood Chemical Company has not defined an intended use or interest in retaining; stabilized sludge staged in a waste cell ("vault") constructed in Lagoon 3; and contaminated soil in Lagoon 1 and 2 which act as a potential source for groundwater contamination. OU1 contains the components of the site which have been judged to pose the greatest potential risk to human health and the environment. Therefore, the approach for addressing OU1 will be to perform a FFS on a fast-track schedule. It is possible to accelerate the RI/FS process for OU1 primarily because limited additional characterization information is required to evaluate potential remedial alternatives. The objective of this fast-track effort is to produce a draft FFS report which documents the evaluation of alternatives for the sludge and soil. In addition, the FFS will document the rationale behind this fast-track study, in terms of both risk and, more specifically, why the no-action alternative is inappropriate for OU1 components. The FFS report will also contain soil clean-up levels for the contaminants of concern, and volume estimates of the quantity of lagoon soils requiring remediation.

The approach for addressing OU's 2, 3 and 4 will be to perform a limited field investigation to fill RI/FS data gaps. The primary objective of the field investigations for these OU's will be to define the nature and extent of contamination in site media to assess the present and future risks to public health and the environment. Although these data also will be useful for evaluating remedial alternatives, the focus of the field investigation scoped in this Work Plan will be to provide the necessary data for a baseline risk assessment and thereby evaluate the no-action alternative for these OU's. If necessary, treatability studies, pilot studies and/or additional activities required to evaluate potential containment or treatment remedial alternatives will be performed in subsequent phases.

1.2 PROJECT BASIS

This Work Plan was prepared in accordance with the following guidance documents and statutes:

- The "Superfund Amendments and Reauthorization Act" requirements.
- "Interim Guidance on Superfund Selection of Remedy", memorandum from J. Winston Porter - EPA Assistant Administrator, OSWER Directive 9355.0-19, December 24, 1986.
- Data Quality Objectives for the RI/FS Process, March 1987.
- "Additional Interim Guidance for FY 87 Records of Decision", memorandum from J. Winston Porter - EPA Assistant Administrator, OSWER Directive 9355.0-21, July 24, 1987.
- Draft Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, OSWER Directive 9335.3-01, March 1988.

In addition, this Work Plan is based on the following site-specific guidance provided by EPA:

- "RI/FS Scoping Meeting Minutes", letter from the REM III Site Manager to the EPA RPM, March 8, 1988.
- "Comments on the Scoping of the RI/FS", letter from the EPA RPM to the REM III Site Manager, May 4, 1988.
- "RI/FS Planning Meeting Minutes", letter from the REM III Site Manager to the EPA RPM, June 6, 1988.
- "Draft Remedial Clean-Up Criteria Document of February 10, 1988 - Greenwood Chemical Site (Task 14)", letter from the EPA RPM to the REM III Site Manager, June 22, 1988.
- "Meeting of June 30, 1988 with John Gorgol of Ebasco re: Greenwood Chemical", letter from the EPA RPM to file, July 1, 1988.

This Work Plan consists of six sections including this introduction (Section 1). The existing information on the Greenwood Chemical Site is summarized in Section 2. The scoping of the RI/FS is described in Section 3. The technical approach for addressing each OU is presented in Section 4. The task plan for performance of the RI/FS and FFS is described in Section 5. The project management approach including a project schedule through the completion of the RI/FS and FFS is presented in Section 6.

2.0 SUMMARY OF EXISTING INFORMATION

2.1 SITE LOCATION/CURRENT CONDITIONS

The Greenwood Chemical Site is located in Albemarle County between Waynesboro and Charlottesville, Virginia approximately 4 miles east of Rockfish Gap in the Blue Ridge Mountain range. The site location is shown in Figure 2-1. Although the site is located less than 1/4 mile from Interstate Route 64, access to the site is from Route 690 via Routes 250 and 796. The site entrance is near the center of the small village of Newtown, Virginia.

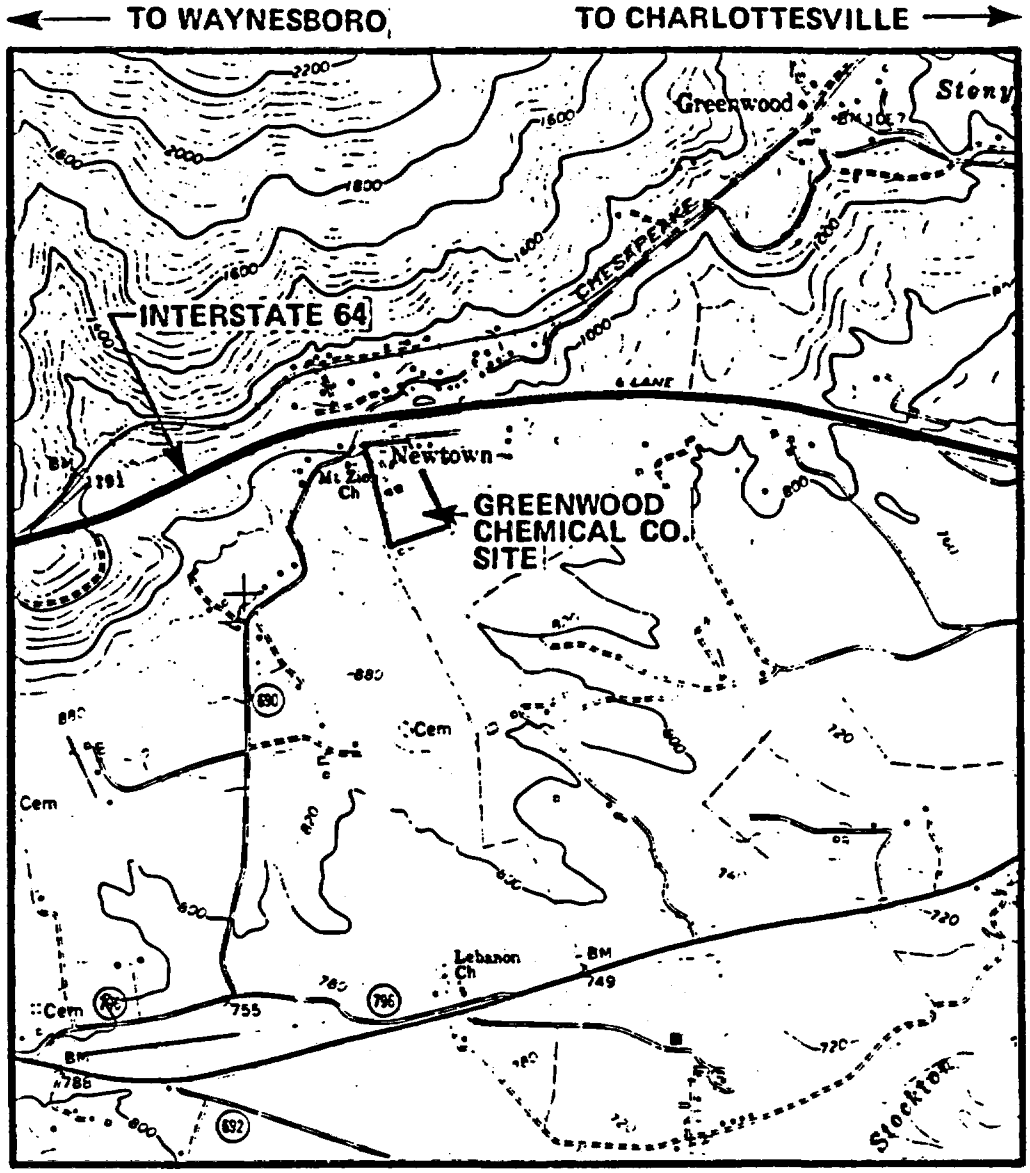
The site consists of approximately 18 acres. It is bounded by: Route 690 and an east/west residential road (dead end) to the north, a wire fence and hedgerow to the east, an intermittent wire fence immediately south of the largest lagoon to the south, and the Mt. Zion Baptist Church property and an intermittent wire fence to the west. The layout of the site is shown in Figure 2-2. The main on-site features include: three main processing buildings, three main warehouse buildings, an office/laboratory building, numerous trailers/storage sheds, an outdoor platform, a pump house, a concrete bunker, five former treatment lagoons (currently backfilled or excavated), two treatment lagoons (full of water), several dilapidated and abandoned structures, and a former buried drum area (all drums have been excavated and removed from the site).

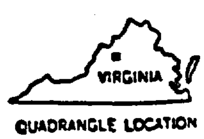
On-site soil contains significant levels of volatile and semi-volatile organic compounds as well as arsenic and cyanide. Soil contamination is generally highest around the process buildings, in Backfill North and Backfill Northeast, at the location of former Lagoons 1 and 2, and in the former buried drum area. The highest levels of groundwater contamination have been detected near Lagoons 1 and 2 and downgradient of the former buried drum area.

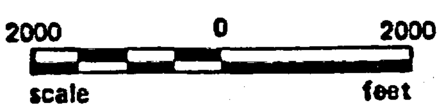
2.2 SITE HISTORY

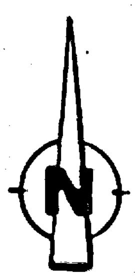
A chronological description of the known history of activities at the Greenwood Chemical Site is presented in Section 2.1 of the "Draft Remedial Clean-Up Criteria for Lagoons 1, 2 and 3" report dated February 10, 1988. Most of that information will not be repeated in this Work Plan.

A variety of chemical products were manufactured at the site during the plant's approximately 38 years of active operation. A comprehensive list of all chemicals handled at the site and/or process flow diagrams are not available. Possible products manufactured during early operations include pharmaceutical









Source: *USGS WAYNESBORO EAST, VA. QUADRANGLE 1:24,000 SERIES*

U.S. ENVIRONMENTAL PROTECTION AGENCY
GREENWOOD CHEMICAL SITE ALBEMARLE, VIRGINIA
FIGURE 2-1 SITE LOCATION MAP
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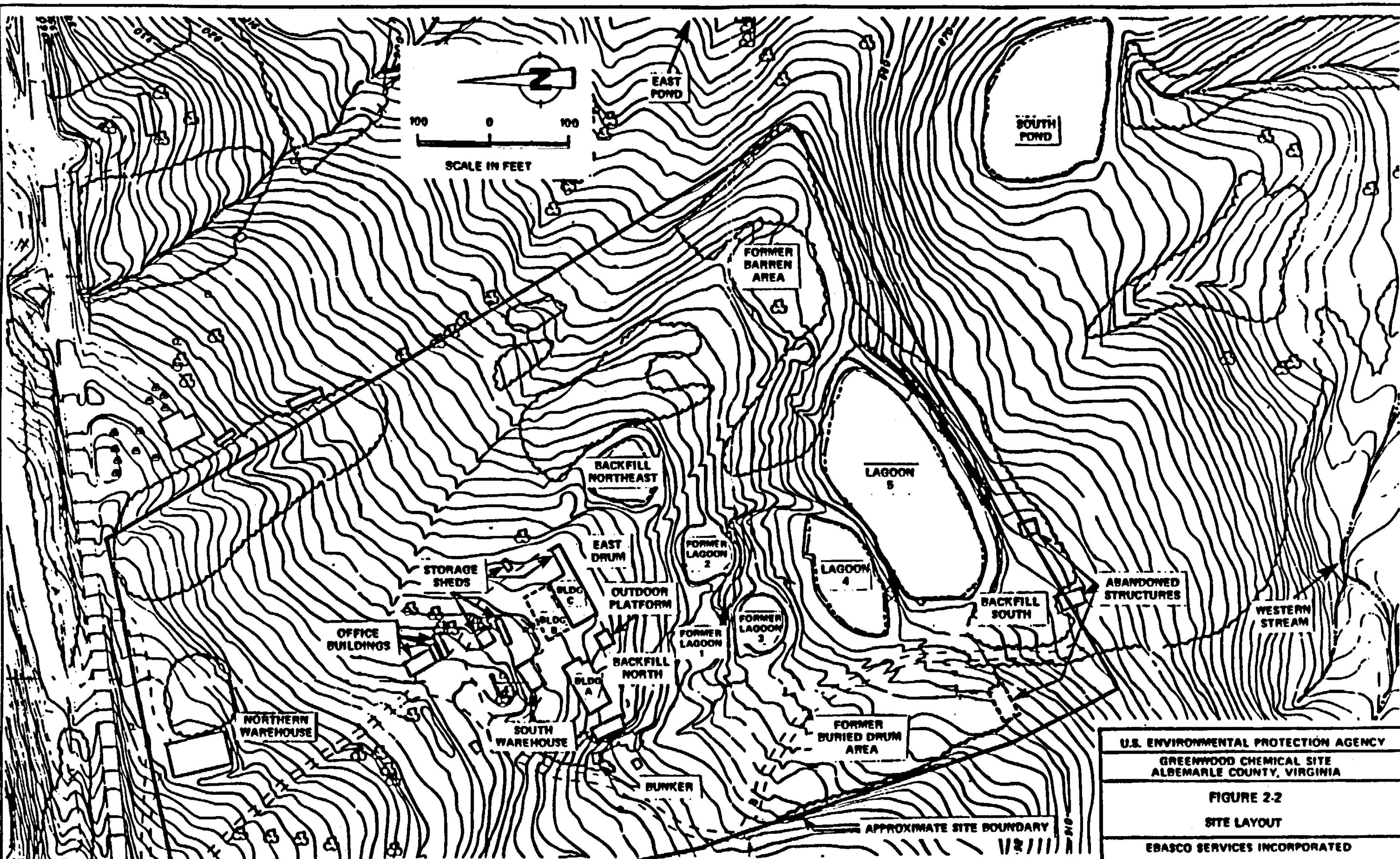

U.S. ENVIRONMENTAL PROTECTION AGENCY

GREENWOOD CHEMICAL SITE
ALBEMARLE COUNTY, VIRGINIA

FIGURE 2-2

SITE LAYOUT

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intermediates, plant growth regulators and photography chemicals. Inorganic arsenic catalysts were allegedly used in a process to produce chloromethylnaphthalene.

During the final years of plant operations at the site, records indicate that chemical processing was organized as follows:

- o Building A was used strictly for the production of Naphthalene Acetic Acid.

- o Building C was used for the following four processes:

    1) Production of Naphthaldehyde via a confidential proprietary process.

    2) Production of 2-Benzoyl pyridine

    3) Purification of the sodium salt of Beta-Naphthalene-Sulfonic-Acid.

    4) Dissolution of organic powder in toluene via another proprietary process.

- o Building B was used only when there was insufficient capacity in Building C.

Highlights of the site history include:

- o There have been three owners since operations began in 1947,

- o Lagoons became active between the 1960's and early 1970's,

- o Drum burial operations took place in the 1970's,

- o Fish and cattle kills occurred which may have been the result of releases from the site,

- o In April 1985, a toluene fire killed four workers and resulted in the shutdown of main operations at the site,

- o A Preliminary Assessment and HRS scoring was performed for the site in May and November 1985, respectively, and

- o EPA installed 19 monitoring wells at the site between late 1986 and early 1987.

EPA performed a time-critical removal action at the site from November 1987 to June 1988. The following activities were performed:

- Approximately 400 buried drums and other containers were excavated, overpacked and removed from the site. Some of the drums and containers were in poor condition. Following drum excavation and removal, the area was backfilled and covered with a layer of 10 mil synthetic sheeting under a layer of seeded topsoil. In addition, a french drain was constructed along the upgradient borders to further prevent surface water from entering the area.

- A significant number of abandoned surface drums were sampled and subsequently removed from the site.

- Sludge and underlying soil from Lagoons 1, 2 and 3 were excavated and stabilized with kiln dust. This stabilized material is currently staged in a vault located in the void created by the excavation of Lagoon 3. The vault is constructed of two layers of 10 mil synthetic sheeting beneath the material and one layer above the material. This upper layer was then covered by seeded topsoil. The depth of the vault averages 6 to 8 feet and it contains approximately 800 cubic yards of material. Prior to lagoon excavation, the water from Lagoons 1, 2 and 3 was treated with activated carbon and released into Lagoon 5.

- Drums and containers in buildings were examined and inventoried. Drums and containers in poor condition which could cause a potential release were overpacked. Other drums and containers were sorted and stored in several on-site buildings.

- Potentially explosive materials were shot and detonated on the site.

- An underground concrete room or bunker was discovered in a bamboo thicket west of the main process buildings. The bunker is currently empty.

- Subsequent to excavation of contaminated sludge and soil, Lagoon 1 was backfilled with 3 to 4 feet of clean soil.

- Access to the main process buildings was restricted by boarding up the windows and locking the doors.

On June 9, 1988, representatives of EPA, the Virginia Department of Waste Management and REM III met at the Greenwood Chemical Site in order to identify remaining overpacked and unmarked drums in the buildings and to determine the status of all process vessels in the buildings. The locations and identification of overpacked and unmarked containers were given to the current owner of the Greenwood Chemical Company. The owner has subsequently specified his intended disposition for each container.

Approximately 60 process vessels of significant size in the main process buildings and outdoor platform were inspected with the exception of two vessels located in an off-limits area (due to ongoing litigation). Whenever possible, process vessels were checked by opening an access panel to visually inspect the intervals. If a visual internal inspection was not possible, a drain valve was opened to test for the presence of liquid in the vessel. Overall, the process vessels inspected were either dry or contained an insignificant amount of residue with the following exceptions:

	Process Vessel Description	Suspected Contents	Estimated Quantity
1)	55-gal drum-Bldg A basement	Toluene/Naphthalene-Acetic-Acid	10 gal
2)	55-gal drum-Bldg A basement	Aqueous Solution of Na Salt of Naphthalene-Acetic-Acid	0-55 gal
3)	~100-gal steel vessel in good condition Bldg. A, 2nd Floor	Naphthalene Dispersion	20 gal
4)	~100-gal metallic tank in good condition-Bldg. B	Pyridine	10-40 gal
5)	~150-gal steel vessel open at top-Bldg. B. This vessel could not be closely inspected because it is located in an off-limits area	Recrystallized Matl.? Rain Water? Solid/Liquid?	100 gal
6)	2-1/2′ dia. x 6′ long grinder in good condition-Outdoor Platform	Solid Residue-Na Salt of Naphthalene-Acetic-Acid	1 ft^3

2.3 SITE DESCRIPTION

The physical environment of the site has been extensively described in the reports from previous investigations at the site. The following discussion is limited to information generated during or subsequent to the removal and May 1988 field sampling activities.

2.3.1 Geology

A discussion of the general geologic setting of the Greenwood Chemical Site, including stratigraphy, structure, and physiographic setting, was contained in the Draft Remedial Clean-up Criteria Document (February 1988) and the ERB/EERU/REAC Well Installation Report (November, 1987). Supplemental geologic information has been obtained concerning three items: the Rockfish Valley fault, overburden thickness and lineaments. Each of these is examined below.

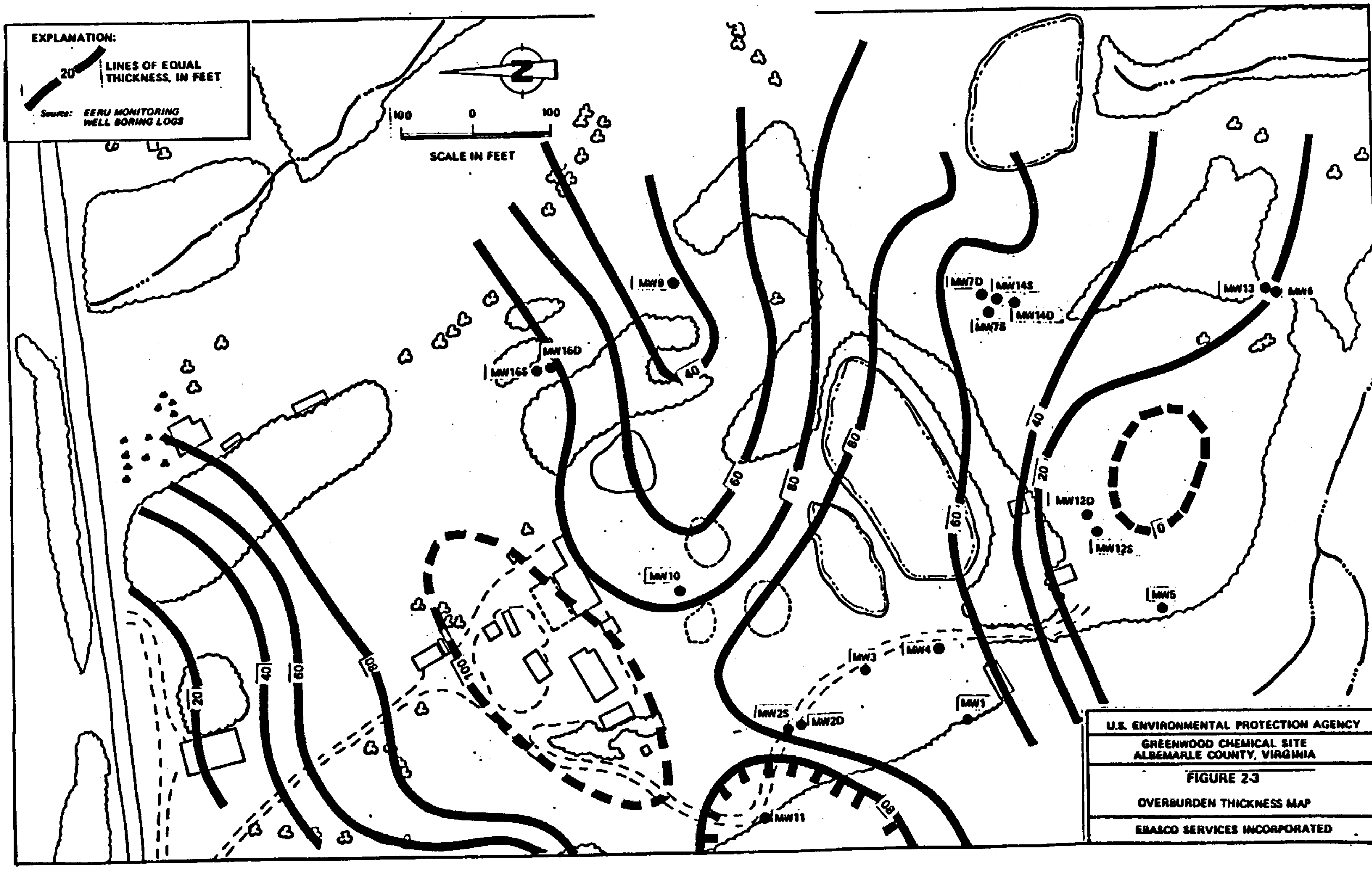
Rockfish Valley Fault

The principal author of the 1977 report on the geology of the Waynesboro quadrangles (T.M. Gathright II) has refined his interpretations regarding the existence of a low-angle thrust fault along the southeastern base of the Blue Ridge Mountains. The Rockfish Valley Fault, as it was originally described, is now believed to represent a "shear contact" between the highly deformed, overturned limb and only slightly deformed, upright limb of a recumbent fold. The overturned limb, consisting of the Lovingston Formation (a mylonitic biotite gneiss), was subjected to relatively intense deformation forces, as evidenced by its mylonitic and augen-bearing textures and more highly developed foliation. The upright limb, consisting of the Pedlar Formation (a granodiorite gneiss), was subjected to considerably less deformation, as evidenced by its coarse-grained, massive texture and lower grade metamorphic facies.

The implications of this reinterpretation regarding the release or migration of contaminants at the Greenwood Chemical Site relate primarily to the common association between faults and zones of high permeability or groundwater flow. The absence of a "fault zone" running northeastward-to-southwestward beneath the site greatly reduces the potential for contaminant transport in these directions.

Overburden Thickness

A revised isopach map of overburden thickness (saprolite and soil) at the Greenwood Chemical Site is shown in Figure 2-3. The map was developed using data from the ERB/EERU boring logs. To fill information gaps between boreholes, the September 1987 seismic data were consulted.


EXPLANATION:
20
LINES OF EQUAL THICKNESS, IN FEET
Source: EERU MONITORING WELL BORING LOGS
N
100 0 100
SCALE IN FEET
MW9
MW16D
MW16S
MW10
MW7D
MW14S
MW7S
MW14D
MW13
MW6
MW12D
MW12S
MW5
MW3
MW4
MW1
MW2S
MW2D
MW11
20
40
60
80
100
0
U.S. ENVIRONMENTAL PROTECTION AGENCY
GREENWOOD CHEMICAL SITE
ALBEMARLE COUNTY, VIRGINIA
FIGURE 2-3
OVERBURDEN THICKNESS MAP
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In general, the isopach map shows a thickening of the overburden toward the center of the site, encompassing both the lagoon and drum disposal area. Thinning occurs to the northwest and north, in response to a change in bedrock lithology from Lovingston to Pedlar (the Pedlar being associated with very thin soil mantles). An outcrop area on the southern slope, is also associated with a larger area of overburden thinning. Overburden thicknesses approach 100 feet in the lagoon area. Average thickness across the site range from 40 to 60 feet. The significance of overburden thickness will be addressed in the hydrogeology discussion.

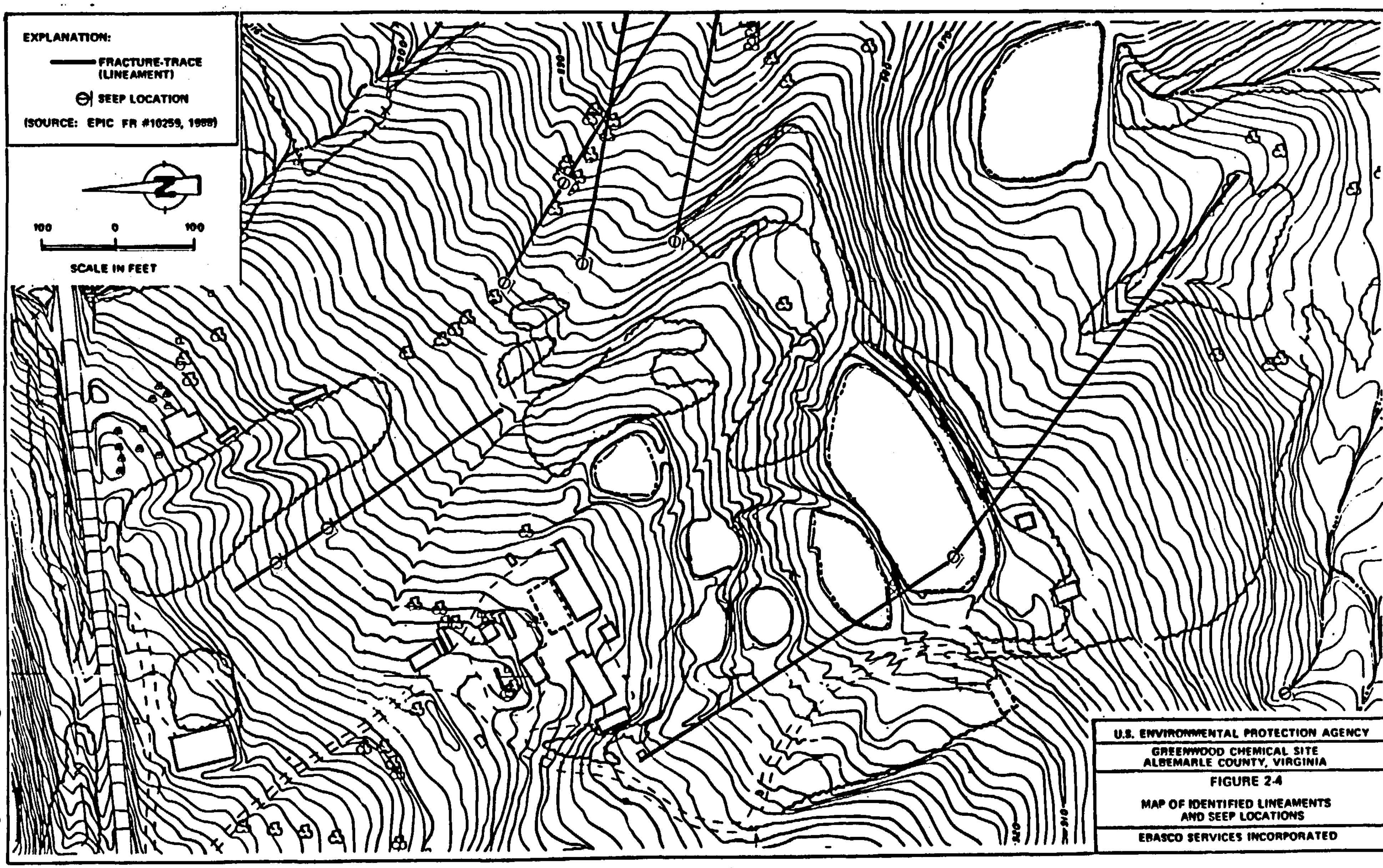
Lineaments

A fracture-trace study of the Greenwood Chemical Site vicinity was completed by the EPA's Environmental Photography Interpretation Center (EPIC). This study identified a number of lineaments in the immediate site area, all with an approximate northwestward-to-southeastward (NW-SE) trend. Six (6) of these lineaments extend through or adjacent to the site (Figure 2-4). The lineaments range in length from 700 to 2200 feet. All but one are located to the east of the process buildings and lagoon area.

The orientation of lineaments identified by EPIC at the Greenwood Chemical Site is similar to that associated with the diabase dikes mapped on the geologic maps of the southern section of the Shenandoah Park and the Waynesboro East Quadrangle (Gathright, 1972; Gathright et al., 1977). It was suggested by the authors of the Waynesboro report that the emplacement of these dikes during the Triassic period may be related to the existence of a regional fracture network. The northwest-southeast orientation of lineaments at the Greenwood Chemical Site is also approximately perpendicular to the dominant cleavage direction in the metamorphic rocks of the area. A similar relationship between prominent joint/fracture directions and cleavage was noted by Gathright et al. (1977). The significance of these lineaments to the Greenwood RI pertains primarily to the flow of groundwater and the location of site monitoring wells. It will be examined again in the discussion of the groundwater OU (OU2).

2.3.2 Hydrogeology

Evaluation of regional and site hydrogeology was detailed in the Draft Remedial Clean-up Criteria for Lagoons 1, 2, and 3 document (February 10, 1988) as well as the ERB/EERU/REAC Well Installation Report (ERB/EERU/REAC, 1987). Supplemental information regarding groundwater flow in the bedrock (both on- and off-site) and the hydraulic connection between bedrock and overburden has been collected. This information is based on data collected during the May 1988 field program and from



U.S. ENVIRONMENTAL PROTECTION AGENCY

GREENWOOD CHEMICAL SITE
ALBEMARLE COUNTY, VIRGINIA

FIGURE 2-4

MAP OF IDENTIFIED LINEAMENTS
AND SEEP LOCATIONS

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ongoing communications with Virginia Division of Mineral Resources geologists. These issues are relevant to the Work Plan discussion because they will guide the location and completion methods for the proposed monitoring wells.

Hydraulic Interconnection

The hydraulic interconnection between saturated bedrock and overburden (or "saprolite") at the Greenwood Chemical Site was first described in the ERB/EERU/REAC Well Installation Report (p. IV-18). Similarities in the distribution and magnitude of contamination detected in Well Clusters 14 and 7 served to further substantiate this interpretation.

Gathright, et al. (1977; p. 30), in a discussion of bedrock recharge, noted the occurrence of "open fractures beneath a fairly well-developed soil profile" along the lower slopes of the Blue Ridge Mountains. Downward percolation and flow through the overburden into these fractures is the principal method of recharge to the fractured bedrock aquifer (Cross, 1962). Water well drillers in the Waynesboro area have long understood the nature of the hydraulic connection between overburden/saprolite and bedrock (T.M. Gathright, personal communication). Accordingly, residential wells are typically sited in areas of thickest saprolite development (and completed within the upper 50 feet of bedrock) to ensure the best yields. The overburden apparently serves as a reservoir for the fractured bedrock below. Cross (1962, p. 2) refers to the overlying saprolite as "...a giant sponge, absorbing groundwater during wet periods and allowing it to percolate slowly downward into the [bedrock] fractures."

This relationship (hydraulic interconnection) between saprolite and bedrock was observed in the Well 14S packer test (conducted by EERU) and during well purging activities at Well Cluster 14 in May 1988 (Well 7D in the saprolite was dewatered during purging of 14S in the bedrock). Similar tests are planned for the RI field program in new monitoring wells to define in greater detail the nature of this relationship.

Bedrock Flow Regime

Because the metamorphic rocks lack primary porosity, groundwater flow in the bedrock is determined by the orientation, size and spatial density of fractures. Two types of fractures have been described in the Waynesboro area (Gathright, et al. 1977). The first and most abundant type are steeply inclined to vertical and highly variable in length. These appear to be related to tectonic stresses associated with folding, faulting and other stress relief mechanisms. The second type are subhorizontal fractures caused by erosional unloading (i.e., removal of overlying rock and resultant release of internal rock pressures). These "release joints" are generally found in the upper 50 feet of bedrock, and usually are most abundant in the uppermost 10 to 15 feet of this interval (Gathright, personal communication).

The best yielding water wells in the area are those that intercept both release joints and the more prominent of the vertical fractures. Fracture-trace (lineament) studies using remote sensing data are often used by the Virginia Division of Mineral Resources for the siting of waterwells in the Waynesboro area. At the Greenwood Chemical Site, a number of lineaments were identified by EPIC (Sec. 2.2.1). The majority of these lineaments trend northwest-southeast, which coincides with topographic slope (southeast) and the predominant direction of groundwater flow in the bedrock (also southeast). The installation and testing of additional bedrock wells along these newly identified lineaments is planned for the RI field program.

The May 1988 groundwater samples from residential wells and bedrock monitoring wells were analyzed for the major anions and cations. These analyses will be used to develop "signatures" for the groundwater in each well with the intent of establishing lateral hydraulic connections (and flow line paths) between both on- and off-site wells. This work is currently scheduled to be completed by EPA researchers at the Robert S. Kerr laboratory.

2.3.3 Climate

The study area has a humid, climate but influenced strongly due to its relative proximity to the Atlantic Ocean. Summers are warm and humid. The warmest month is July with an average daily maximum temperature of 85°F. The winters are cool. The average daily maximum temperature for December, January and February is 37°F. The average daily minimum temperature for the same months is 28°F. The average annual precipitation is 45.72 inches. The one-year 24-hour rainfall event, according to the National Weather Service's Rainfall Frequency Atlas, is 3.25 inches. Precipitation is most abundant during the May through August period. The driest months are November through February.

2.3.4 Environmental Resources

The Draft Community Relations Plan for the Greenwood Chemical Site (Ebasco 1988) contained a discussion of the population and land use in the vicinity of the site. Environmental resources were also addressed briefly in that document. The population and resource factors of most significance to the Greenwood RI/FS are the type and extent of groundwater usage in the site area.

There are approximately 50 residences in the village of Newtown and the area bounded by State Roads 690, 250, and 651 that potentially could be affected by releases from the site.

Twenty-one of the residential wells in the vicinity of the site have been sampled for complete TCL analyses (Table 2-1). Seven wells have been sampled twice. Potential site-related contamination has been detected in several of these wells. This contamination is addressed in Section 2.4.2.

All but one of the residential wells sampled were bedrock wells. Typical well completion methods in this area entail casing of overburden and open-hole completions in the rock; well screens are rarely, if ever used. Completion data are not available for most of these wells but published information indicates that depths typically range from 50 to 250 feet (Cross, 1962; Gathright et al. 1977). Most wells are completed in the upper 50 feet of bedrock; very few penetrate more than 300 feet of rock.

The groundwater used by most local residents is of sufficient quality to preclude treatment. Iron filters were reportedly used on some of the residential water systems near the site. Staining, coloration in the water, and sediment were common problems associated with these iron-contaminated wells. There is no public water supply system available to the residences in the vicinity of the site and potential surface water supplies are intermittent. As a result, the groundwater is an important resource for this area.

2.4 EXISTING SITE CHEMICAL DATA

The following review of existing site chemical data is limited to that generated subsequent to the REM III Interim Field Investigation of September 1987. The results of that investigation and a summary of previous site data are presented in the Draft Remedial Clean-Up Criteria for Lagoons 1, 2 and 3 document (February 10, 1988). Site chemical data generated since September, 1987 include results of sampling efforts completed by EPA Technical Assistance Team (TAT) personnel in

December, 1987 and EPA REM III personnel in May, 1988. Results from these two sampling efforts are presented below.

A summary of sampling locations for all existing site chemical data are presented in Figure 2-5.

TABLE 2-1
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
RESIDENTIAL WELL SAMPLING

	NAME	EERU/TAT 05/87	REM III 09/87	REM III 05/88
1.	Banks	X	X	
2.	Coles		X	
3.	Community Center	X	X	
4.	Estate/Carriage			X
5.	Fentress	X		X
6.	Fix			X
7.	Hurst			X
8.	Gibson		X	X
9.	Josepthal		X	
10.	Mt. Zion Church		X	
11.	Nakasian		X	
12.	New House			X
13.	Nobles		X	X
14.	Simmons	X		X
15.	Simms		X	X
16.	Sproken			X
17.	Steppe		X	
18.	Wallace		X	
19.	B. Washington			X
20.	J. Washington			X
21.	Woods		X	

2.4.1 EPA - TAT Former Lagoon and Buried Drum Area Sampling - December, 1987

Samples were collected from the excavated sludge and remaining soil in Lagoons 1, 2 and 3. Composite soil samples were also collected from corners of a 50 foot square grid in the former buried drum area. Samples were analyzed for full TCL organics, TAL inorganics, cyanide and various other characterization tests. Concentrations of Tentatively Identified Compounds were not reported.

Lagoon sludge and soil sampling results are summarized in Table 2-2. Sludge samples were collected from the kiln dust stabilized material that is currently located in the on-site vault. Sludge samples from all three lagoons contained high concentrations of volatile organics, semi-volatile organics, and arsenic. Numerous compounds from all contaminant classes were detected at concentrations which exceeded preliminary remedial action levels. General contaminant trends of decreasing concentration levels moving from Lagoons 1 to 3 were consistent with previous data. Other data presented in Table 2-2 are for surface (approximately 0-2 feet) soil and shallow subsurface (approximately 2-4 feet) soil samples collected from the soil which was previously under the lagoons and is currently at the surface in those areas. Significant levels of volatile organics, semi-volatile organics, arsenic and cyanide which exceed preliminary remedial action levels remain in the soil in the areas of former Lagoons 1 and 2. Soil samples from the area of former Lagoon 3 exhibited much lower concentrations which were relatively independent of depth below land surface.

Although only averaged results are shown in Table 2-2, soil samples were collected from two different locations within each former lagoon area. Contaminant concentrations varied considerably with horizontal location for the soil from the Lagoon 1 area. Contaminant concentrations for samples collected from the inlet area of Lagoon 1 were an order of magnitude higher than those from samples collected further from the inlet. This same trend regarding variability with distance from the inlet was exhibited by the samples from the Lagoon 3 area. Sampling results from the Lagoon 2 area were not a strong function of horizontal location.

Soil sampling results from the former buried drum area are shown in Table 2-3. Composite samples from the four corners of four 50' squares were collected from surface soil (approximately 0-2 feet). Shallow subsurface (approximately 2-4 feet) samples were also collected from the center of each grid square. Samples were collected from soil which was backfilled following buried drum removal. The majority of this soil was originally on top of and around the buried drums. Sampling results are generally variable with no clear contaminant concentration

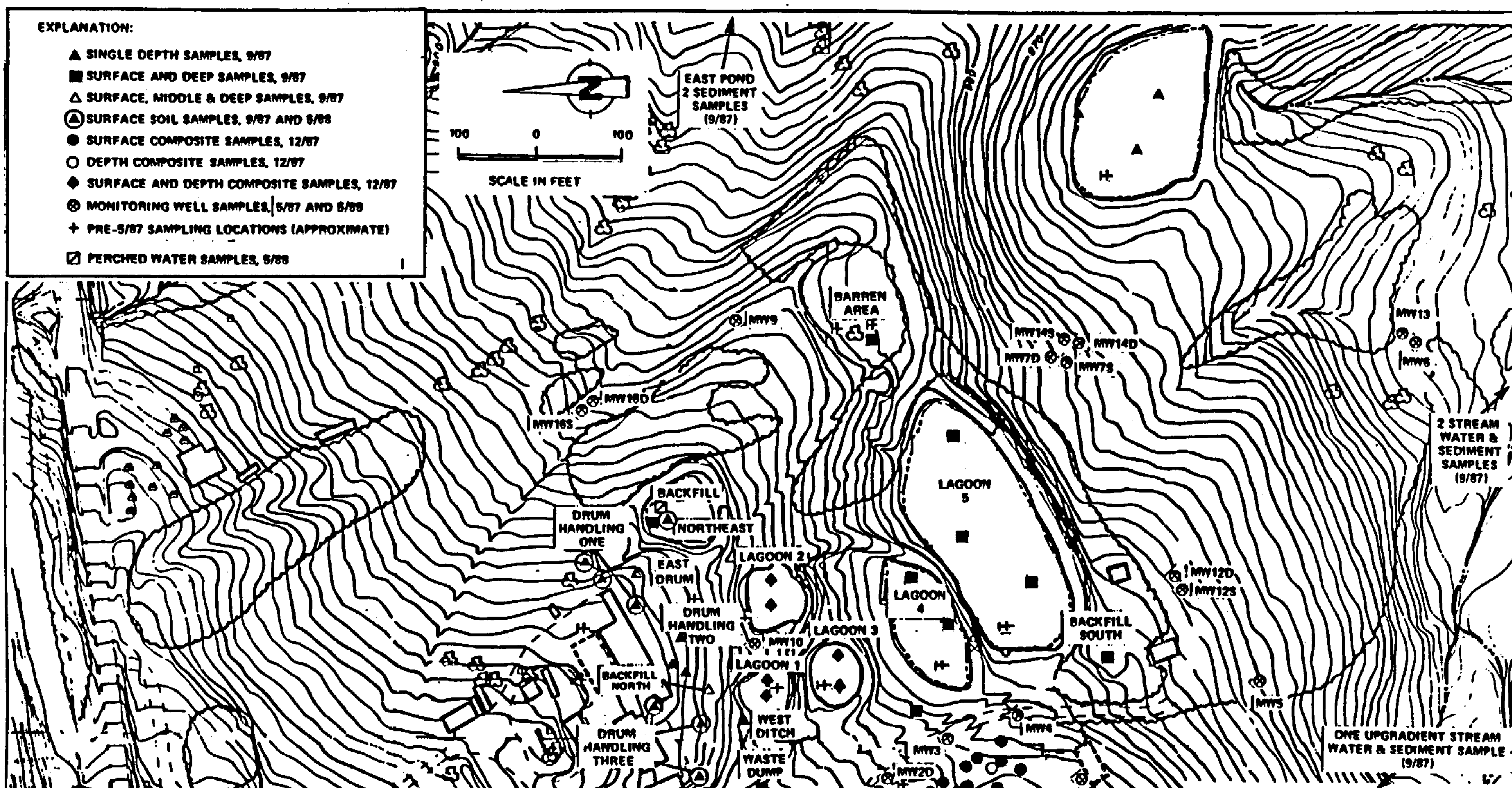
TABLE 2-2

GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN

EPA-TAT LAGOON SLUDGE/SOIL SAMPLING RESULTS - DECEMBER 1987

	SLUDGE			SURFACE SOIL			SHALLOW SUBSURFACE SOIL		
SELECTED CONTAMINANTS	Lagoon 1	Lagoon2(a)	Lagoon3(a)	Lagoon1(a)	Lagoon2(a)	Lagoon3(a)	Lagoon1(b)	Lagoon2(b)	Lagoon3(b)
VOC (ug/kg)									
methylene chloride	2,342	626	454	1,356	1,647	354	2,213	513	610
chloroform	483	55	7	270	--	5	3	15	15
1,1,1 trichloroethane	--	202	--	--	758	--	--	--	--
trichloroethylene	59	--	--	--	--	--	8	12	--
benzene	5,388*	2,344*	17	3,414*	925*	--	2,455*	641*	--
tetrachloroethene	4,044	591	93	23,347	545	5	9,852	2,095	--
1,1,2,2 tetrachloroethane	4,052*	541*	73*	17,470*	514*	4*	9,364*	1,792*	--
toluene	14,410	19,742	3,265	18,118	23,840	1,227	11,966	6,285	754
chlorobenzene	19,992*	5,585	832*	18,899*	12,774*	80*	15,354*	6,312*	12
ethylbenzene	1,950	1,042	55	4,892	1,747	20	2,140	2,482	26
Total Reported VOC	52,720	30,728	4,796	87,766	42,750	1,695	53,355	20,147	1,417
BNA (ug/kg)									
naphthalene	804,900*	160,783*	109,783	91,915	98,557	8,705	318,544*	18,062	9,871
pyrene	--	--	--	1,234	77,667	--	--	--	--
N-nitrosodiphenylamine	--	--	--	4,645	--	--	--	--	--
2-chloronaphthalene	--	--	--	514	--	--	--	--	--
phenol	--	--	--	5,390	--	--	856	--	--
dinitrophenol	--	--	--	7,867	--	--	1,769	--	--
dinitrotoluene	--	--	--	--	--	--	5,453	--	--
Total Reported BNA	804,900	160,783	109,783	111,565	176,224	8,705	326,622	18,062	9,871
METALS AND CYANIDE (mg/kg)									
arsenic	58*	43*	113*	210*	46*	46*	99*	23*	24*
cyanide	NR	33*	46*	97*	415*	16*	376*	44*	2

NOTES: (a) Average of 2 Samples
(b) Average of 3 Samples
* Exceeds Preliminary Remedial Action Levels
-- Below Detection Limits



U.S. ENVIRONMENTAL PROTECTION AGENCY
GREENWOOD CHEMICAL SITE
ALBEMARLE COUNTY, VIRGINIA

FIGURE 2-5
PREVIOUS SAMPLING LOCATIONS

EBASCO SERVICES INCORPORATED

trends with horizontal or vertical location. As indicated on Table 2-3, concentrations of chlorobenzene, arsenic and cyanide exceed preliminary remedial action levels for a portion of the samples.

2.4.2 EPA-REM III Interim Sampling Results-May 1988

The objectives of the May 1988 sampling program were: to initially characterize the nature of the arsenic and cyanide present in the on-site soils, to measure current contaminant levels in the groundwater at the site, to sample eleven additional residential wells in the vicinity of the site, and to resample a residential well for which previous sampling indicated low levels of inorganic contamination.

Soil samples were collected from the northeast backfill area and two drum handling areas. Previous sampling results from these areas indicated significant levels of total arsenic and cyanide. These soil samples were analyzed for TAL inorganics, cyanide, arsenite/arsenate, free and dissociable cyanide, cation exchange capacity, ASTM shake test for arsenic and cyanide, corrosivity, reactivity and EP Toxicity. Perched water from the northeast backfill area was also sampled and analyzed for TCL organics, TAL inorganics and cyanide. All 19 on-site and off-site monitoring wells were sampled and analyzed for TCL organics, TAL inorganics (both total and dissolved) and cyanide. Samples from eleven residential wells were analyzed for TCL organics, TAL inorganics and cyanide. A sample from one residential well was analyzed for pesticide/PCB's and TAL inorganics. In addition, groundwater samples from all bedrock wells were analyzed for selected cations and anions.

Results of the arsenic and cyanide characterization tests for the soil samples are presented in Table 2-4. Quantities of both arsenite and arsenate were detected in the soil samples. In all of the samples, with one exception, arsenate concentrations exceeded arsenite concentrations. The highest levels of the more mobile arsenite valence state were detected in the samples from the northeast backfill area.

Results of the two leaching tests for arsenic are consistent with the valence delineation analyses. For both the ASTM shake test and EP Toxicity test, arsenic concentrations above detection limits were observed only in the samples from the northeast backfill area. The results of the ASTM shake test also indicate that cyanide was detected in the leachate above background only in samples from the northeast backfill area; however, total cyanide concentrations in the soil samples from the other areas were significantly lower. Results of the free and dissociable cyanide analyses indicate a significant component of the total cyanide in the bakfill northeast area is

TABLE 2-3

GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN

EPA-TAT FORMER BURIED DRUM AREA SOIL SAMPLING RESULTS - DECEMBER 1987

	SURFACE SOIL					SHALLOW SUBSURFACE SOIL				
SELECTED CONTAMINANTS	Background	Upper/Near	Upper/Far	Near	Far(a)	Background	Upper/Near	Upper/Far	Near	Far
VOC (ug/kg)										
methylene chloride	83	303	82	22	117	13	421	456	31	165
chloroform	11	16	--	10	--	6	--	--	8	--
1,1,1 trichloroethane	--	--	--	--	--	--	--	--	--	29
benzene	--	7	--	--	--	--	56	--	5	--
tetrachloroethene	--	155	9	--	--	--	692	--	29	9
toluene	15	7,758	2,367	394	287	19	11,430	187	1,398	2,211
chlorobenzene	--	266*	7	--	8	--	2,463*	--	106*	56*
ethylbenzene	--	38	13	--	--	--	179	--	29	10
Total Reported VOC	109	8,543	2,478	426	412	38	15,241	643	1,606	2,480
BNA (ug/kg)										
naphthalene	--	48,026	19,533	22,367	9,957	--	3,397	8,732	37,743	8,361
isophorone	717	--	--	--	--	--	--	--	552	--
anthracene	--	--	--	--	1,800	--	--	--	--	--
fluoranthene	--	--	--	--	1,399	--	--	--	--	--
2-chloronaphthalene	--	520	--	--	--	--	--	--	--	--
2-nitrophenol	--	--	3,065	--	--	--	--	--	--	--
2,4-dichlorophenol	--	--	546	--	--	--	--	--	--	--
Total Reported BNA	717	48,546	23,144	22,367	13,156	--	3,397	8,732	38,295	8,361
METALS AND CYANIDE (mg/kg)										
arsenic	--	24*	29*	--	--	--	46*	22*	--	--
cyanide	NR	5*	4*	NR	NR	NR	4*	2*	NR	NR

NOTES: --: Below Detection Limits
NR: Not Reported
* : Exceeds Preliminary Remedial Action Levels
(a): Average of Two Samples

TABLE 2-4

GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN

EPA-REM III INTERIM SAMPLING RESULTS - MAY, 1988

	SAMPLE LOCATIONS						
	BACKFILL NORTHEAST			DRUM HANDLING AREA 1		DRUM HANDLING AREA 3	
	SAMPLE 1	SAMPLE 2	SAMPLE 20	SAMPLE 1	SAMPLE 2	SAMPLE 1	SAMPLE 2
TOTAL SOIL ANALYSES (mg/kg)							
Arsenic	158	110	110	38	35	76	92
Barium	<120	<120	<120	217	219	437	343
Cadmium	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Chromium	40	< 28	31	67	43	210	467
Lead	<100	<100	<100	140	<100	609	462
Selenium	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Silver	< 40	< 40	< 40	< 40	< 40	< 40	< 40
Cyanide	1410	5.9	838	130	41	12	9
ARSENIC VALENCE STATE (mg/kg)							
Arsenate	20.1	13.4	--	13.8	36.8	155	136
Arsenite	96.9	12.8	--	2.4	3.5	34.1	32.8
ASTM SHAKE TEST (ug/l)							
Arsenic	136	124	185	< 10	< 10	< 10	< 10
Cyanide	495	749	436	< 10	< 10	< 10	< 10
FREE AND DISSOCIABLE CYANIDE (mg/kg)							
Free and Dissociable Cyanide	956	899	790	5.7	8.0	3.3	0.8
Total Cyanide	1410	5.9	838	130	41	12	9
EP TOXICITY ANALYSES (ug/l)							
Arsenic	477	140	90.2	<44.0	<44.0	<44.0	<44.0
Barium	< 6.9	< 6.9	< 6.9	178	146	251	167
Cadmium	< 4.2	< 4.2	< 4.2	< 4.2	< 4.2	<45.0	<12.0
Chromium	< 9.8	< 9.8	< 9.8	< 9.8	< 9.8	< 9.8	< 9.8
Lead	<91.0	<91.0	<91.0	<91.0	<91.0	<91.0	<91.0
Selenium	<49.0	<49.0	<49.0	<49.0	<49.0	<49.0	<49.0
Silver	12.8	9.7	11.8	< 9.6	< 9.6	10.4	< 9.6
OTHER ANALYSES							
Cation Exchange Capacity (MEQ/100G)	140	140	150	16	16	16	14
Corrosivity (Std. Units)	9.3	9.7	9.7	5.5	5.2	5.4	5.8
Reactive Cyanide (mg/kg)	< 1.0	< 5.4	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Reactive Sulfide (mg/kg)	< 20	< 20	< 20	< 20	< 20	< 20	< 20

free and dissociable (and therefore bioavailable). Elsewhere, the proportion of free and dissociable is considerably less. Cation exchange capacity was an order of magnitude higher for the northeast backfill soil relative to the samples from the drum handling areas.

Results of inorganic and organic analyses for the perched water samples from the Backfill Northeast area are presented in Table 2-5. Relatively high concentrations of toluene (180 mg/kg) and semivolatiles TICs (328 to 454 mg/kg) were detected. Because these samples were analyzed as high hazard samples, detection limits were in the 5 to 10 mg/kg range, considerably higher than that used for lower concentration aqueous samples.

Analytical results for the groundwater samples collected from the on-site and off-site monitoring wells are presented in Appendix A. Contaminant trends were consistent with the previous sampling results from the EPA hydrogeologic investigation of 1987. The highest levels of volatile organic contamination were observed in MW-1, MW-4 and MW-10. Contaminant concentrations exceed promulgated standards for benzene, trichloroethylene and other volatile organic compounds in these wells. MW-1 and MW-4 are overburden wells located immediately downgradient of the former buried drum area, while MW-10 is located in the vicinity of former Lagoons 1, 2 and 3. The concentration of total TCL volatile organics in MW-1 roughly doubled between May, 1987 and May, 1988. Significant levels of volatile organics were also detected in the bedrock well samples in the MW-7 and MW-14 clusters.

Significant levels of semi-volatile compounds (composed predominantly of Tentatively Identified Compounds) were detected in the monitoring wells with levels as high as 17 ppm (total) in MW-10. Although not shown in the tables in the Appendix, all pesticide/PCB concentrations were below detection limits with the exception of a reported value of 1.8 ppb for endosulfan II for the sample from MW-14D. Arsenic levels were below the contract detection limit for all filtered monitoring well samples. Low arsenic levels (32 ppb) were observed in several of the unfiltered monitoring well samples. Cyanide was observed above its detection limit in samples from MW-1 and MW-10 at levels of 12 and 16 ppb respectively.

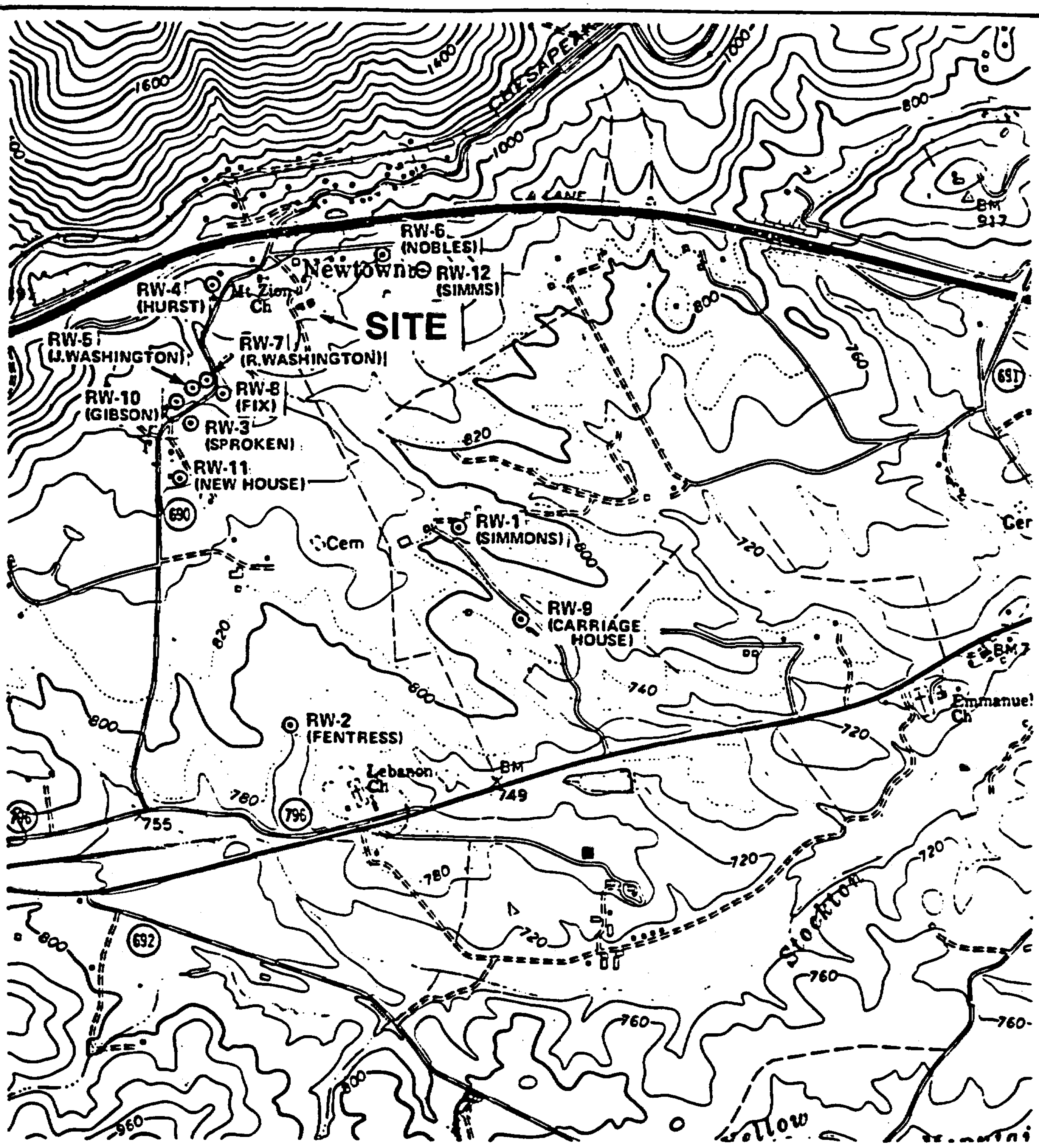
Results of the analyses of the groundwater samples collected from the residential wells are presented in Appendix A. Sampling locations are shown in Figure 2-6. TCL organics were not observed above detection limits with the exception of methylene chloride, acetone and bis-2-ethyl-phthalate which were all identified as being present in the blanks. Arsenic was not observed above its detection limit of 3 ppb. Cyanide was detected in RW-5, RW-8 and RW-9 at concentrations of 12, 12 and 14 ppb respectively. Slightly elevated lead levels were reported for some of the residential well samples.

TABLE 2-5
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
EPA REM III INTERIM SAMPLING RESULTS - MAY 1988

	PERCHED WATER FROM BACKFILL NORTHEAST(1)	
	Sample 1	Sample 2
Volatiles (mg/kg)		
Methylene Chloride	5.2 B	8.6 B
Acetone	8.5 JB	12 JB
2-Butanone	14 B	15 JB
Toluene	180	180
Semivolatiles (mg/kg)		
Naphthalene	3.5 J	2.4 J
TICs (mg/kg)		
Total S-V TICs	328 J	454 J
Inorganics (mg/kg)		
Aluminum	2080	1050
Iron	2110	797
Magnesium	ND	935
Silicon	3490	1410

Note: (1) Samples were analyzed as high hazard samples which requires the reporting of concentrations in units of mg/kg (high hazard assumes matrix is largely non-aqueous).

B = analyte found in blank
J = estimated value
ND = Not Detected



2000 0 2000

scale feet

Source: USGS WAYNESBORO EAST VA. QUADRANGLE 1:24,000 SERIES

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GREENWOOD CHEMICAL SITE ALBEMARLE, VIRGINIA

FIGURE 2-6

LOCATION OF RESIDENTIAL WELLS MAY, 1988 SAMPLING

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3.0 SCOPING OF THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY FOR THE GREENWOOD CHEMICAL SITE

3.1 PRELIMINARY RISK ASSESSMENT

A Preliminary Risk Assessment (PRA) of Lagoons 1, 2 and 3 was performed by Ebasco as part of Task 14 (Draft Remedial Clean-up Criteria for Lagoons 1, 2 and 3, February, 1988). In the Task 14 PRA, several potential human exposure pathways to chemicals present in soils and groundwater at the Greenwood Chemical Site were qualitatively and initially quantitatively evaluated. Chemicals and exposure pathways relevant to each OU are discussed in detail below by summarizing the results of the Task 14 PRA and by updating the identification of chemicals of potential concern and the exposure pathways by operable unit. The Task 14 assessment was expanded using the additional data gathered since the completion of the Task 14 document, including data collected during the recent EPA removal action activities and during the May 1988 interim field investigation.

Operable Unit 1: Drums, Containers and Lagoon Soils

Remaining drums and containers of materials are stored in on-site buildings. The buildings are locked to prevent access to and contact with materials. Those materials not retained by the Greenwood Chemical Company for use within a reasonable time will be removed by EPA.

The potential for Lagoons 1, 2 and 3 soils to be a source of contamination of groundwater was discussed in the Task 14 PRA. Concentrations of several VOCs detected in groundwater samples (see next section for compound identity) collected during the September 1987 interim field investigation and during the May 1988 interim field investigation, particularly samples collected from wells drilled in the overburden, exceeded MCL values. Semivolatile chemicals (e.g., PAHs, nitrophenols, pentachlorophenol, dichlorobenzene) were also detected in groundwater samples collected at the site. Several VOCs (toluene, xylene, methylene chloride, chloroform, benzene, tetrachloroethene, 1,1,2,2-tetrachloroethane, chlorobenzene, ethylbenzene, and trichloroethylene) and semivolatile chemicals (PAHs, N-nitrosodiphenylamine, phenol, dinitrophenol, and dinitrotoluene) were also detected in soils of Lagoons 1, 2 and 3.

Methylene chloride and acetone, however, were also detected in blanks at similar concentrations and are therefore not considered to be chemicals of potential concern for VOC-contaminated soils. In addition, benzene, trichloroethene (TCE), and tetrahydrofuran were detected in overburden groundwater and may have originated from the lagoon soils. Of the chemicals of potential concern detected in soils, chloroform, benzene, tetrachloroethene, trichloroethene, dinitrotoluene, and tetrachloroethene are potential carcinogens; all other VOCs of concern present noncarcinogenic health impacts.

Soils from Lagoons 1, 2 and 3 are therefore considered an apparent source of both VOC and semivolatile groundwater contamination. Subsequent ingestion of this contaminated groundwater is a pathway of concern for soils. In addition, the Task 14 PRA also sited inhalation of volatile gases released to the air from contaminated soils as a potential exposure pathway of concern for downwind off-site residents and potential future on-site residents. Direct contact with VOC-contaminated soils or wind entrainment of contaminated dust with subsequent inhalation may be significant pathways for the nonvolatile chemicals of concern. These two pathways are not significant for VOCs in soils since these chemicals would volatilize readily once they were on the soil surface and are generally not strongly sorbed to particulate material.

<u>Operable Unit II: Groundwater, Pond and Creek Surface Water, and Lagoons 4 and 5</u>

<u>Groundwater</u>: As discussed above, sampling conducted during the May 1988 interim field investigation showed overburden groundwater contamination with methylene chloride, acetone, chloroform, TCE, benzene, 4-methyl-2-pentanone, toluene, carbontetrachloride, tetrachloroethene, tetrahydrofuran, 4-methyl-2-pentanol, chlorobenzene, vinyl chloride, 1,2-dichloroethane, ethylbenzene, naphthalene, benzyl alcohol, 2-nitrophenol, 4-nitrophenol, n-nitrosodiphenylamine, 4-chloroaniline, 2-methylnaphthalene, acenaphthene, pentachlorophenol, pyrene, dichlorobenzene, benzoic acid, and xylenes. Several tentatively identified compounds (TICs) were also detected in the semivolatile fraction of the groundwater analyses. The tentative identification of these chemicals indicates that they may be associated with historical site operations. Bedrock wells also exhibited contamination with some of these chemicals. Residential wells, most of which are placed in the bedrock aquifer, showed no detectable contamination with positively identified volatile or semi-volatile chemicals during either the May 1988 interim field investigation or during the sampling conducted as part of Task 14. Toluene and a small number of semivolatile TICs detected in residential wells were also detected in the blanks and therefore are not believed to be site-related. Inorganic chemicals were also detected in groundwater at and near the site, with aluminum, total arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, nickel, total cyanide, and vanadium included as inorganic chemicals of potential concern.

Of the chemicals of potential concern listed above for groundwater, methylene chloride, carbon tetrachloride, chloroform, 1,2-dichloroethane, TCE, benzene, tetrachloroethene, vinyl chloride, and arsenic are potential carcinogens. The other chemicals of potential concern noted above exhibit primarily noncarcinogenic effects.

Exposure to the groundwater in the overburden, while not considered likely due to expected low yields of wells completed in the overburden, may in the future be used as a source of drinking water; therefore, ingestion of this groundwater is of concern. The bedrock aquifer is the aquifer into which most local residents have placed potable water wells; although contamination with the above-mentioned contaminants was less than levels detected in the overburden, there is communication between the aquifers, and the ingestion of groundwater from the bedrock aquifer is also of concern. Hydrogeological characteristics of the site will be defined in detail in the RI.

<u>Ponds</u>: Based on sampling conducted under Task 14, no site-related contamination of the sediments was detected in either the east or south pond except for low concentrations of a small number of tentatively identified compounds (TICs). While both the identification and reported concentrations of these compounds are suspect; based on historical site practices, these types of chemicals may be expected. They are therefore considered to be chemicals of potential concern for the pond sediments at the Greenwood Chemical Site. Surface water samples of the ponds were not collected during the interim field investigations. Based on current sampling results, contact with sediments in these ponds during swimming, wading, or fishing may be of concern. These ponds may be used as a water source for terrestrial life and may have fish; however, due to apparent low levels of contamination compared with on-site levels, no significant adverse ecological impacts are expected from these exposures.

<u>Creeks</u>: One upstream sample, one sample at the site, and one downstream sample were collected from the west stream during the September 1987 interim field investigation, and the stream was not sampled during the May 1988 interim investigation. Volatile organic chemicals detected in the west stream sediments and water were primarily common laboratory contaminants [acetone, methylene chloride, toluene, bis(2-ethylhexyl)phthalate (DEHP), etc.] which were also detected in blanks at similar level; therefore, as discussed in the Task 14 document, ingestion of surface water from the western stream is not considered an exposure pathway of concern. In addition, direct contact with stream sediments, although it may occur, is not considered significant since low levels of sediment contamination were detected. The ecological use of the creek water (i.e., presence of fish, use as a drinking water source for terrestrial life and as a water source for various plants) may be significant.

Lagoons 4 and 5: Sediment samples collected from Lagoons 4 and 5, the two remaining lagoons on site, during the September 1987 interim field investigation showed detectable concentrations of toluene, trans-1,2-dichloroethene, TCE, chlorobenzene, xylene, 4-methyl-2-pentanone, DEPH, naphthalene, 2-methylnaphthalene, pyrene, aniline, 2-chloraniline, and several phenolic compounds as well as several inorganics including arsenic, chromium, iron, lead, vanadium, zinc, and total cyanide. In addition, Lagoon 4 had at least a few benzene- and naphthalene-derived TICs identified. Water samples were not collected during that investigation. As stated previously, although the identification and measured concentration of these TICs are suspect, they may be products or by-products of past site operations and are therefore considered as chemicals of potential concern in the lagoons. Of these chemicals of potential concern, TCE, DEHP, and arsenic are potential carcinogens, while the other chemicals identified above exhibit primarily noncarcinogenic effects.

The only cyanide analytical results currently available are for total cyanide. The free component of cyanide (i.e., HCN or CN^-) is the biologically available form and thus the toxic agent. Therefore, the total cyanide concentrations detected currently in the lagoons does not provide information concerning the fraction of total cyanide present as free or weak and dissociable cyanides. This subject is discussed in more detail in Section 3.3. Concerning the total arsenic measurements currently available, it should be noted that, based on certain physical-chemical properties, various forms or species of arsenic are considered more bioavailable than others. Arsenic present as arsenate, for instance, is considered to be less mobile and less bioavailable than arsenite, because arsenate is more strongly bound to soil or other solids. Arsenic may interconvert from one species to another; however, tests are available to determine the relative quantity of arsenate and arsenite present in various media at a point in time, which will allow finer tuning of the risk assessment.

Aerial photographs used for the EPIC lineament study indicate that Lagoon 5 is probably fed by a groundwater seep (spring). Due to the existence of contaminated groundwater in wells upgradient of the Lagoon (e.g., MW-10), groundwater discharging into Lagoon 5 may be contaminated. The impact of this discharge has not been fully determined, as only one round of surface water sampling at Greenwood has occurred (6/85).

Under the no-action alternative, human exposure pathways of concern for these lagoons include exposure while swimming or wading in the ponds. Although small fish may exist in Lagoon 5, ingestion of these fish is unlikely. Potential off-site exposure to site contaminants via overflow from the lagoons during storms and the subsequent transport may be of concern;

however, limited data are currently available concerning chemical constituents in the lagoon water. Environmental pathways (e.g., use of lagoons as sources of drinking water by birds or terrestrial wildlife; plant growth in and around the lagoons) may be of concern; however, confirmational testing of the lagoon water would have to be performed prior to the exposure pathway being considered complete.

Operable Unit III: Other Soils: Chemicals of potential concern identified for the on-site soils in the Task 14 PRA were total arsenic, lead, total cyanide, toluene, xylene, and naphthalene. These soils include samples from the Drum Handling Area, Surface Drum Area, Backfill North, Backfill South, Backfill Northeast, East Drum Area, Barren Area, West Ditch, and the Waste Dump. Other chemicals of potential concern which may be identified based on data from the September 1987 interim field investigation and the May 1988 interim field investigation are naphthalenic compounds, benzoic acid, chloroform, ethylbenzenes, benzene, tetrachloroethene, phenolic compound, DEHP, PAHs, several volatile and semivolatile chlorobenzenes, arsenic, cadmium, chromium, copper, lead, manganese, and mercury. Additionally, in the May 1988 interim field investigation, the speciation of arsenic and cyanide was investigated to aid in determining the potential bioavailability, fate, and transport of these chemicals.

The arsenic speciation results indicate that arsenic is present as both arsenite (As^{+3}) and arsenate (As^{+5}) in varying ratios in the backfill northeast and in the drum handling area. The ratio of free and dissociable to total cyanide also varies with the greatest amount of free and dissociable cyanide being present in the backfill northeast area. Several TICs were also present, particularly in the semi-volatile analytical fraction, which may contribute to the risks for exposed individuals. While the identification and calculated concentrations of these TICs in soils are necessarily uncertain, historical site practices supports their presence at the site. Of the chemicals of potential concern presented above, those considered to be carcinogens by either the oral or inhalation route are benzene, tetrachloroethene, DEHP, the carcinogenic PAHs, arsenic, cadmium (inhalation only), and chromium (inhalation only). The other chemicals of potential concern are considered to be noncarcinogens.

As identified in the Task 14 PRA, exposure pathways of concern for the contaminated soils include ingestion of groundwater which has received contaminants leached from the soils (and/or surface water fed by discharge of contaminated groundwater), direct contact with on-site soils (incidental ingestion and dermal absorption) by on-site individuals; inhalation of airborne contaminated particulate material by on-site and off-site individuals, and inhalation of chemicals volatilized from soils in various areas at the site. Another potential exposure pathway noted in the Task 14 PRA, ingestion of milk from cows which uptake soil contaminants while grazing, may be of concern, particularly if the site were to be used in the future as a grazing area.

Operable Unit IV: Underground Structures

There is very little information currently available to determine the potential for exposure to possible chemicals in underground structures at the site. The only available information from sampling are magnetic anomalies. There are plans, however, for test pits to be dug during the RI. If these underground structures are present at the site, and if they contain wastes, they may be a source of groundwater and soil contamination if they are leaking. Therefore, they may be an indirect contributor to the exposure of individuals via ingestion of contaminated groundwater or via direct contact with subsurface soils (if the subsurface soils are disturbed).

3.2 DATA GAPS FOR RISK ASSESSMENT/REMEDIAL CLEANUP LEVELS

This section identifies the sampling and analytical data gaps based on the PRA summarized above. These gaps will be discussed for each OU; however, several gaps apply to media in each OU. The collection of a statistically significant number of background and site samples for determination of naturally occurring levels is necessary for almost every OU. For risk assessment purposes, chemicals detected in less than 5% of samples are assumed to not be representative of overall site conditions and are not considered as chemicals of potential concern. OU-specific data gaps are discussed below.

Operable Unit 1

Additional data need to be collected during the RI to define the extent of surface (for direct contact) and subsurface (for leaching to groundwater) soil VOC and semivolatile contamination remaining in those areas in which removal activities have taken place (e.g., former Lagoons 1, 2, and 3).

As part of Task 16, the FFS for OU1, soil cleanup criteria for VOCs, semivolatiles and inorganics based on protection of groundwater need to be developed. Cleanup criteria developed as part of Task 14 will be finalized and compared with the levels of VOCs, semivolatile chemicals and inorganics currently detected in the surface and subsurface soils at the site to determine the extent of remedial action that is appropriate for the soils based on groundwater protection.

Operable Unit 2

To aid in identifying chemicals of potential concern in groundwater from the two aquifers at the Greenwood Chemical Site, a statistically significant number (i.e., equal to or greater than three) of background samples from each aquifer will be collected. These background samples will aid in determining if site inorganic sample results are significantly elevated above background or are present at naturally occurring levels. Most groundwater samples collected during the May 1988 interim field investigation had no detectable cyanide at detection limits of 10 ug/liter. Detected levels, seen primarily in off-site residential wells, were between 10 and 15 ug/liter. The Virginia groundwater standard for cyanide is 5 ug/liter. Detection limits on the cyanide analytical methods must be below the Virginia groundwater standards. It should be noted that Virginia groundwater standards for phenols, cadmium, and mercury are also less than EPA contract-required quantitation limits; therefore, modifications to analytical methods for those chemicals must be made to achieve detection limits below groundwater standards. At least 10% of the groundwater samples collected will be analyzed for free and dissociable cyanide as well as total cyanide.

As discussed in Section 3.1, only one upstream sample, one sample at the site, and one downstream water/sediment samples were collected from the West Stream. In order to statistically determine whether site samples of naturally occurring chemicals in West Stream are significantly elevated above background (upstream) samples, at least three upstream surface water/sediment samples and three downstream surface water/sediment samples should be collected. A greater number of samples from the West Stream surface water and sediments is generally needed since it is difficult to fully characterize the potential impact of the site contamination on the stream based on so few sample results. Because neither cyanide nor arsenic were detected in either the West Stream or the ponds, speciation analyses for these two chemicals in these surface water bodies are not recommended.

As discussed in Section 3.1, only limited surface water sampling has been performed for Lagoons 4 and 5 to date. In addition to run-off, the lagoons may be receiving contaminated groundwater from submerged seeps. The exposure pathways of potential concern for these lagoons concern direct contact with these surface waters and the potential use of the water by ecological receptors, surface water samples should be collected. In addition, total cyanide and arsenic were detected in the sediments of Lagoon 4 during the September 1987 interim field investigation; therefore, the additional samples will be analyzed for both free and dissociable cyanide and total arsenic.

Operable Unit 3

Soil-related exposure pathways of concern (e.g., direct contact) are dependent upon surface soil contaminant concentration; therefore, soil samples will be collected at 0- to 4- or 6-inch depths. In order to determine the completeness of the exposure pathway dealing with ingestion of cow's milk and/or beef, surface soil samples in pastures adjacent to the Greenwood Chemical Site will be collected as well.

The Backfill Northeast area and the Drum Handling Area contained generally the highest concentration of arsenic and cyanide; therefore, soil samples collected during the May 1988 interim field investigation were analyzed for free, dissociable, and total cyanides, and arsenite, arsenate, and total arsenic. The results of cyanide speciation analyses area not yet available; however, the results of the arsenic speciation analyses in these two areas indicated that while the ratio of arsenite to arsenate appears consistent within a particular site study area, a site-wide ratio cannot be predicted. In addition, results of the first interim field investigation indicate that detectable levels of total arsenic and total cyanide were also found in soils of the surface drum, upgradient, backfill north and backfill east, east drum, west ditch, and waste dump area. At least 10 percent of the soil samples from each study area at the site will be analyzed for the specific forms of arsenic and cyanide potentially present.

Operable Unit 4

As discussed in Section 3.1, sampling of test pits is needed to confirm that underground structures exist. If the underground structures exist, sampling of the contents of the structures as well as the soils and groundwater in the vicinity of the structures is necessary in order to determine whether these structures are indirect sources of contamination to which individuals may be exposed.

3.3 PRELIMINARY SCOPING OF REMEDIAL ACTION ALTERNATIVES

The general environmental concerns associated with the Greenwood Chemical Site are the presence of volatile and semi-volatile organic contaminants, arsenic and cyanide in lagoon sludges, surface and subsurface soils, and groundwater. To a lesser extent, the presence of numerous containers of chemicals and/or waste products and the possible existence of underground structures containing similar materials also present a potential threat to public health and the environment. Separation of the site into operable units (as described in Section 1.1) and initiation of a FFS for OU1 is intended to facilitate an expedited response to the most urgent of these concerns (i.e., the sludges and highly contaminated soils in OU1). Development of appropriate alternatives involving various remedial technologies has begun for this OU. These activities are addressed in greater detail under the Task 16 discussion in Section 5.13.

For the remaining operable units, the scoping of specific remedial action alternatives and technologies is judged to be premature at this time. The assembly and screening of alternatives for OU's 3 and 4 will be conducted only if the RI and risk assessment findings indicate that such activities are warranted.

3.4 DETERMINATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

The following discussion on the identification and consideration of ARARs is limited to contaminant-specific ARARs alone. A more complete evaluation of these as well as action-specific and location-specific ARARs and "To Be Considered" requirements will be developed during initial feasibility study activities.

3.4.1 Selection of ARARs

Site sampling and analysis activities have produced an extensive chemical characterization of the wastes and media at the Greenwood Chemical Site. In order to identify contaminant-specific ARARs, a list of site contaminants was drawn up and compared with Federal and Virginia State statutes containing contaminant-specific standards or criteria. For the Greenwood Chemical Site, contaminant-specific standards or criteria were found in the following statutes:

- o Safe Drinking Water Act (Maximum Contaminant Levels)
- o RCRA Groundwater Protection Standards (Maximum Concentration Limits)
- o Clean Water Act (Ambient Water Quality Criteria for the Protection of Human Health and Aquatic Organisms)
- o Virginia Water Quality Standards (Surface Water Standards for Surface Public Water Supplies, Water Quality Criteria for Surface Water, and Groundwater Quality Standards)

It was determined that some type of promulgated criterion or standard was available for approximately 35 of the more than 50 primary contaminants at the site.

A more detailed analysis of these statutory provisions will be completed for the RI/FS. Based on the preliminary review, Safe Drinking Water Act MCLs are expected to be applicable requirements; Virginia State Groundwater Quality Standards are expected to be potential ARARs. The extent to which surface water criteria are relevant and appropriate depends on the intended or designated use(s) of the affected surface waters at the site. The potential proximity of the site to natural trout streams and/or surface public water supplies may affect the status of these standards at the site.

For those contaminants where State/Federal standards or criteria do not exist, other promulgated criteria, guidance and advisories may be useful in developing and evaluating remedial alternatives. Appropriate criteria, guidance and advisories may include those promulgated or developed by EPA, other Federal agencies, and the State of Virginia, including the following:

- o Safe Drinking Water Act - Maximum contaminant Level Goals (MCLGs)
- o USEPA Drinking Water Health Advisories
- o USEPA Health Effects Assessment
- o Cancer Assessment Group (National Academy of Science) Guidance

A complete review of these "To Be Considered" requirements will be accomplished during the RI/FS.

3.4.2 Consideration of ARARs During the RI/FS

ARARs will be examined several times during the execution of the Greenwood Chemical Site RI/FS and FFS. It is expected that additional contaminant-specific ARARs (and/or other guidance and criteria) will be identified as potentially applicable technologies and alternatives are developed for the the FFS and OU2, 3 and 4 FS for the site. Specifically, ARARs will be considered at six key intervals:

1) Task 1 - Project Planning: ARARs will be considered when determining the data to be collected in the field investigation. ARARs will also be considered in the development of sampling and analysis plans, particularly where ARARs may require special analyses and/or more sensitive detection limits (e.g., when Virginia State standards are below standard detection limits for TCL compounds).

2) Task 6 - <u>Assessment of Risks</u>: ARARs will be considered during the analysis of risk to public health and the environment.

3) Task 9 - <u>Development of Remedial Response Objectives and Response Actions</u>: Compare site data base to ARARs.

4) Task 9 - <u>Identification of Applicable Technologies and Development of Alternatives</u>: Utilize ARARs specific to site conditions for development of action levels, specific response objectives, and remedial alternatives. Also, identify ARARs that apply to the formulated alternatives.

5) Task 9 - <u>Screening of Remedial Technologies/-Alternatives</u>: Consider ARARs when assessing the effectiveness of an alternative.

6) Task 10 - <u>Detailed Evaluation of Remedial Alternatives</u>: Evaluate each alternative to the extent it attains or exceeds ARARs.

The conclusions regarding ARARs reached at these intervals will be used as a guide to evaluate the appropriate extent of site cleanup and to aid in screening and evaluating proposed treatment technologies.

A listing of Federal and State standards and criteria that are potential contaminant-specific ARARs for the Greenwood Chemical Site is shown in Table 3-1. The site contaminants for which standards or criteria are listed were selected on the basis of detection in either soil, surface water or groundwater. However, ARARs were identified only for surface water and groundwater.

TABLE 3-1
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
PROMULGATED STANDARDS AND CRITERIA FOR THE CONTAMINANTS DETECTED AT THE GREENWOOD CHEMICAL SITE

CONTAMINANT		CLEAN WATER ACT - WATER QUALITY CRITERIA (a)					VIRGINIA STATE WATER CONTROL LAW WATER QUALITY STANDARDS (b)		
		PROTECTION OF HUMAN HEALTH			PROTECTION OF AQUATIC LIFE				
	Safe Drinking Water Act MCL (c)	Ingestion of Drinking Water	Ingestion of Drinking Water & Aquatic Organisms	Ingestion of Aquatic Organisms Only	Fresh-water Acute	Fresh-water Chronic	Surface Water Standards for Public Surface Water Supplies (d)	Water Quality Criteria for Surface Water(e)	Ground Water(f)
VOLATILE ORGANICS									
Acetone	--	--	--	--	--	--			
Benzene	5	0.66	0.66	40	2,500**	--			
2-Butanone	--	--	--	--	--	--			
Carbon Tetrachloride	5	0.42	0.40	6.9	35,000	--			
Chlorobenzene	--	488	488	15,050	--	--			
Chlorinated Benzenes	--	--	--	--	250	50			
1-Chlorobutane	--	--	--	--	--	--			
Chloroform	100	0.19	0.19	18	28,900	1,200			
1,2-Dichloroethane	5	0.94	0.94	243	110,000	20,000			
Ethylbenzene	--	2,400	1,400	3,280	32,000	--			
Isocyanomethane	--	--	--	--	--	--			
Methylene Chloride	--	--	--	--	--	--			
4-Methyl-2-Pentanone	--	--	--	--	--	--			
Tetrachloroethene	--	0.88	0.8	8.9	5,200	840			
Tetrahydrofuran	--	--	--	--	--	--			
Toluene	--	15,000	14,300	424,000	17,500	--			
Trichloroethene	5	2.8	2.7	81	45,000	21,000			
Trimethylborane	--	--	--	--	--	--			
Vinyl Chloride	2	--	2.0	53	--	--			
Xylenes (total)	--	--	--	--	--	--			
SEMI-VOLATILE ORGANICS									
Acenaphthene	--	--	--	--	1,700**	500**			
Benzoic Acid	--	--	--	--	--	--			
Benzyl Alcohol	--	--	--	--	--	--			
bis(2-chloroethyl)ether	--	0.03	0.03	--	--	--			
4-Chloroaniline	--	--	--	--	--	--			

ll concentrations in ug/l

300953

TABLE 3-1 (Continued)
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
PROMULGATED STANDARDS AND CRITERIA FOR THE CONTAMINANTS DETECTED AT THE GREENWOOD CHEMICAL SITE

CONTAMINANT		CLEAN WATER ACT - WATER QUALITY CRITERIA (a)					VIRGINIA STATE WATER CONTROL LAW WATER QUALITY STANDARDS (b)		
		PROTECTION OF HUMAN HEALTH			PROTECTION OF AQUATIC LIFE				
	Safe Drinking Water Act MCL (c)	Ingestion of Drinking Water	Ingestion of Drinking Water & Aquatic Organisms	Ingestion of Aquatic Organisms Only	Acute	Chronic	Surface Water Standards for Public Surface Water Supplies (d)	Water Quality Criteria for Surface Water(e)	Ground Water(f)
Chrysene	--	--	--	--	--	--			
Chlorinated Naphthalenes	--	--	--	--	1,600**				
Dichlorobenzene	--	470	400	2,600	1,100**	760**			
Hexachlorobenzene	--	--	--	--	--	--			
2-Methylnaphthalene	--	--	--	--	--	--			
2-Methylphenol	--	--	--	--	--	--			
Naphthalene	--	--	--	--	2,300	--			
2-Nitrophenol	--	--	--	--	230**	150**			
4-Nitrophenol	--	--	--	--	230**	150**			
n-Nitrosodiphenylamine	--	7.0	4.9	16	--	--			
Pentachlorophenol	--	1,010	1,010	29,400	20	13			
Phenanthrene	--	--	0.00072	0.00074	--	--			
Pyrene	--	--	--	--	--	--			
INORGANICS									
Antimony	--	146	146	450,000	9,000	1,600	--	--	--
Arsenic (total)	50	0.0025	0.0022	0.0175	--	--	50	--	50
Arsenic (III)	--	--	--	--	360	190	--	190	--
Arsenic (V)	--	--	--	--	850**	48**	--	--	--
Barium	1,000	--	--	--	--	--	1,000	--	1,000
Beryllium	--	--	--	--	100	5.3	--	--	--
Cadmium	10	10	10	--	3.9	1.1	10	(g)	0.4
Chromium (total)	50	--	--	--	--	--	50	--	50
Chromium (VI)	--	50	50	--	16	11	--	11	--
Copper	--	--	--	--	18	12	1,000	(g)	1,000
Iron (soluble)	--	--	--	--	--	--	300	1,000	--
Lead	50	50	50	--	80	3.2	50	(g)	50
Manganese (soluble)	--	--	--	--	--	--	50	--	50 (h)
Mercury	2	10	0.144	0.146	2.4	.012	2	0.05	0.05
Nickel	--	15.4	13.4	100	1,400	160	--	(g)	--

ll concentrations in ug/l

TABLE 3-1 (Continued)
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
PROMULGATED STANDARDS AND CRITERIA FOR THE CONTAMINANTS DETECTED AT THE GREENWOOD CHEMICAL SITE

CONTAMINANT		CLEAN WATER ACT - WATER QUALITY CRITERIA (a)					VIRGINIA STATE WATER CONTROL LAW WATER QUALITY STANDARDS (b)		
		PROTECTION OF HUMAN HEALTH			PROTECTION OF AQUATIC LIFE				
	Safe Drinking Water Act MCL (c)	Ingestion of Drinking Water	Ingestion of Drinking Water & Aquatic Organisms	Ingestion of Aquatic Organisms Only	Acute	Chronic	Surface Water Standards for Public Surface Water Supplies (d)	Water Quality Criteria for Surface Water(e)	Ground Water(f)
Selenium	10	10	10	--	260	35	10	35	10
Silver	50	50	50	--	4.1	0.12	50	--	none
Thallium	--	17.8	13	48	1,400**	40**	--	--	--
Zinc	--	5,000	--	--	320	110	5,000	47	50
Cyanide	--	200	200	--	22	5.2	--	5.2	5.0
Phenols	--	3500	3,500	769,000	10,000**	2,500**	1.0	1.0	1.0
pH	--	--	--	--	--	--	--	--	5.5-8.5

otes: All values in ug/l

(a) Clean Water Act; 304, Water Quality Criteria
(b) Virginia State Water Control Law, Water Quality Standards (VRG680-21-03, VRG680-21-04, VRG680-21-05)
(c) RCRA, Groundwater Protection Standard Maximum Concentration Limits are a subset of SDWA MCLs
(d) Standards apply at the intake and in designated reaches upstream and downstream of the intake as well as tributaries within a specified distance
(e) Criteria are for protection of aquatic organisms
(f) Standards apply to all groundwater occuring at and below the uppermost seasonal limits of the water table. Virginia also has an anti-degradation policy for groundwater that is currently under revision.
** Insufficient data to develop criteria. Value presented is Lowest Observed Effect Level (LOEL)

4.0 TECHNICAL APPROACH

The technical approach to completing the RI/FS and FFS for the Greenwood Chemical Site focuses on identifying risk and engineering related data gaps and the appropriate investigative, analytical and evaluation methodologies needed to fill these gaps. A scoping and technical approach matrix (Table 4-1) was developed to summarize both the types of information needed to meet the goals of the RI/FS as well as the methods to obtain and evaluate this information.

4.1 OPERABLE UNIT 1 - FFS

Operable Unit 1 was defined to include the components of the site which pose the greatest potential risk to human health and the environment. Therefore, the OU1 will be addressed through a FFS on a fast-track schedule. The objectives and activities included in the FFS are described in Section 5.13. The technical approach will include determining the extent of contaminated lagoon soils and sludges through additional surface and subsurface soil sampling and analyses. Also, the current drum/container inventory and other associated information will be confirmed.

4.2 OPERABLE UNIT 2 - GROUNDWATER AND SURFACE WATER

The majority of activities associated with the investigation of Operable Unit 2 focus upon determining the direction and rates of groundwater flow, and the existing and expected distribution of contamination along these pathways. In developing an approach to collect this information to define the hydrogeologic regime and current/future extent of contamination, the following data gaps were identified:

- Bedrock fracture distribution
- Permeability distribution in both bedrock and overburden
- Hydraulic interconnection of bedrock and overburden
- Hydraulic interconnection of bedrock wells along fractures
- Contaminant distribution between bedrock and overburden
- Water levels of bedrock and overburden

Ten new monitoring wells will be installed, tested, and sampled during the field investigation for the purpose of determining the above information. Four (4) wells will be installed in bedrock, six (6) wells will be installed in the overburden.

TABLE 4-1
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
TECHNICAL APPROACH AND SCOPING MATRIX

OPERABLE UNIT	SOURCE/ MEDIA	LOCATION	TYPES OF CONTAMINANTS	DATA GAPS: RISK	DATA GAPS: ENGINEERING	INVESTIGATIVE TECHNIQUES	POTENTIAL REMEDIAL OBJECTIVES
1	Containers	On-Site Buildings		Chemical contents, intended usages	Container integrity, inventory, building access	Confirm inventory & intended usages	Mitigate threat of release to the environment
	Sludge/Kiln Dust	Former Lagoon 3 (Vault)	VOCs S-V Org Arsenic Cyanide	Waste concentrations, leachability	Waste volume, treatability	Sample collection and analysis	Mitigate threat of groundwater release
	Soils/Sludge in Former Lagoons & Backfill Area	Lagoon 1 Lagoon 2 Backfill North	VOCs S-V Org Arsenic Cyanide	Contaminant concentrations, contaminant leachability, extent of contamination	Soil volume, treatability	Sample collection and analysis	Mitigate threat of groundwater release, direct contact, surface water release, air release
2	Groundwater	Onsite	VOCs S-V Org	Contaminant concentrations, extent of contamination, background groundwater quality, groundwater usage	Plume dimensions & volume, controls on groundwater flow in saprolite, fracture distribution in bedrock, hydraulic interconnection between aquifers & within bedrock, contaminant partitioning data, groundwater treatability	Install monitoring wells, collect/ analyze soil & rock samples, conduct geophysical, aquifer & tracer tests, collect/analyze groundwater samples, conduct groundwater flow & transport modeling, conduct well inventory	Mitigate threat of present and potential future public use of contaminated groundwater and/or contaminant discharge to surface waters
	Surface Water	Lagoons 4 & 5, Seeps, Farm Ponds, West Stream	VOCs (minor)	Surface water concentrations, background surface water quality, surface water/ groundwater relationships, impact of contaminated groundwater discharge into surface water bodies	Volume of contaminated surface water, runoff volume	Collect & analyze surface water samples from lagoons, ponds and West Stream	Mitigate threat associated with recreational or consumptive uses (including livestock) of surface water

TABLE 4-1 (Continued)
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
TECHNICAL APPROACH AND SCOPING MATRIX

OPERABLE UNIT	SOURCE/ MEDIA	LOCATION	TYPES OF CONTAMINANTS	DATA GAPS: RISK	DATA GAPS: ENGINEERING	INVESTIGATIVE TECHNIQUES	POTENTIAL REMEDIAL OBJECTIVES
2 (cont'd)	Stream Sediment	West Stream	Possibly VOCs Metals Cyanide S-V Org	Presence/absence of hazardous substances, effects of removal action on stream bed	Volume of contaminated sediment	Sample 3 upgradient and 3 downgradient locations	Mitigate threat of release to surface water or groundwater
3	Soil	Onsite and in site vicinity	VOCs S-V Org Metals Cyanide	Surface & subsurface soil contaminant types and concentrations, extent of contamination areally & vertically, background soil concentrations, contaminant leachability (or partitioning), fugitive dust & volatilization potential prevailing winds	Volume, density and treatability of contaminated surface & subsurface soils	Drill 16 soil borings, 10 monitor well borings, and 9 auger borings. Collect & analyze soil samples for organic, inorganic contaminants, geochemical parameters and geotechnical properties	Mitigate threat of direct contact and/or releases to surface water, groundwater and air
4	Underground Structures	6 Onsite Magnetic Anomalies	Unknown	Presence/absence of hazardous substances, extent of contamination in adjacent soils	Dimensions, depth, condition of structures	Excavate 6 test pits, sample as appropriate	Mitigate threat of release to soil/groundwater, assess if an emergency condition is present

To the maximum extent practicable, bedrock well locations were chosen to provide both contaminant distribution and hydraulic parameter data along major fracture-traces. However, only two of the EPIC lineaments were found to extend through the primary area of interest at the site. Two of the bedrock wells (MW-17D and MW-20D) are located along lineaments; the remaining two (MW-18D and MW-21D) are located in a general downgradient direction from source areas or contaminated wells.

Bedrock well MW-17D was sited along a fracture-trace near the northern warehouse to investigate potential contamination from waste-related activities in this area. MW-17D may also provide valuable hydrogeologic data concerning fracture distribution and flow in the Pedlar Formation (the Pedlar-Lovingston contact is believed to lie south of the northern warehouse). Wells MW-18D and MW-20D are expected to intercept groundwater that has flowed beneath or through the major source areas at Greenwood (i.e., process area, backfilled areas and lagoons). Well MW-21D is expected to define the southeastern extent of bedrock contamination detected in wells MW-14S and MW-14D. Well MW-14D will be completed as a 2-inch PVC well to eliminate the current potential for downhole cross-contamination.

Five of the six proposed overburden wells are paired with bedrock wells (MW-17S, MW-18S, MW-20S, MW-21S, and MW-6R). In addition to contaminant distribution and groundwater flow in the overburden, these wells will also be used to evaluate the hydraulic interconnection between bedrock and overburden.

Monitoring wells MW-18S, MW-19, and MW-20S are located downgradient of the backfill and/or lagoon areas. Wells MW-18S and MW-20S are expected to intercept groundwater flowpaths from the lagoon areas; MW-19 will serve to delineate the southwestern extent of the plume emanating from the buried drum area. MW-20 is also expected to intercept flow from the former drum disposal area, due to overburden thinning (and bedrock outcrops) and a resulting eastward bending of flowlines to the south of this area.

Monitoring well MW-17S will investigate possible contamination from activities near the northern warehouse. If samples from MW-17S are clean, this well can be used as a source of upgradient (background) groundwater quality for the overburden. Monitoring well MW-21S will investigate the southeastern extent of contamination in the overburden that was detected in MW-7S and MW-7D. Monitoring well 6R will be a replacement for improperly-constructed, existing well MW-6. The rationale for the selection of the well locations and completion depths is summarized in Table 4-2.

The following sequence of drilling, sampling, and testing activities will be performed at these wells during the field investigation:

TABLE 4-2
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
OPERABLE UNIT 2 (GROUNDWATER)
MONITORING WELLS

MONITORING WELLS	LOCATION	RATIONALE/JUSTIFICATION: GROUNDWATER QUALITY	RATIONALE/JUSTIFICATION: HYDROGEOLOGIC CHARACTERIZATION
OVERBURDEN WELLS			
17S	Southeast of Northern Warehouse	Investigate possible contamination associated with past activities in/near warehouse; if clean, provide upgradient groundwater quality data	Water level data for gradient/flow direction determinations; slug test data (possible change in overburden character due to change in bedrock lithology)
18S	South of Backfill Northeast; Southeast of Process Buildings	Investigate possible contamination downgradient of backfilled and process areas	Water level and slug test data for gradient, flow direction & velocity and hydraulic conductivity calculations; provide additional details concerning migration/flow in overburden from source areas; provide bedrock-overburden hydraulic connection data
19	Southwest of former buried drum area	Investigate southwestern extent of contaminant plume emanating from former buried drum area	Water level data for gradient/flow direction; provide data from region of inferred groundwater divide
20S	Southwest of Well Clusters 14 and 7; Southeast of Lagoon 5	Determine plume geometry associated with saprolite wells 6, 7S, and 7D	Investigate flow paths from Wells 1 and 4 toward southeast (around bedrock outcrop area), providing a mechanism to account for contamination in Well 6; will be used to assess hydraulic connection between bedrock and overburden; provide water level and slug test data
6R	Adjacent to Existing Well 6	Provide reliable groundwater quality data from below water table (current well sand pack extends to surface)	Water level and slug test data for gradient, flow direction/velocity and hydraulic conductivity calculations;
21S	South of South Pond; Southeast of MW-7 and MW-14 well cluster	Define southeastern extent of overburden contamination detected in wells MW-7S and MW-7D	Water level data for gradient/flow direction deterIminations; slug test data for hydraulic conductivity and velocity calculations; provide overburden-bedrock hydraulic connection data

TABLE 4-2 (Continued)
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
OPERABLE UNIT 2 (GROUNDWATER)
MONITORING WELLS

MONITORING WELLS	LOCATION	RATIONALE/JUSTIFICATION: GROUNDWATER QUALITY	RATIONALE/JUSTIFICATION: HYDROGEOLOGIC CHARACTERIZATION
BEDROCK WELLS			
17D	Southeast of Northern Warehouse	Investigate possible deeper contamination associated with activities near warehouse; if clean, provide upgradient groundwater quality data (may be completed in Pedlar Formation)	Determine flow paths along lineament; provide fracture, hydraulic head, and velocity data; comparative analysis for Pedlar vs Lovingston aquifer parameters
18D	South of Backfill Northeast; Southeast of Process Area and Backfill North	Investigate possible deeper contamination downgradient of source areas; define eastern (and possibly northern) limits of plume detected in Well Cluster 14 and expected to extend northwestward beneath lagoons	Determine flow paths & possible migration pathways downgradient from source areas; provide fracture and hydraulic head data; estimates of groundwater velocity; determine hydraulic connection & gradients between bedrock and overburden (using Well 18S)
20D	Southwest of Well Clusters 14 and 7; Southeast of Lagoon 5	Investigate possible deeper contamination along major EPIC-identified lineament downgradient from lagoons; define western limits of plume identified in Well Cluster 14	Determine flow paths & possible migration pathways along major lineament passing through lagoon area; provide fracture, hydraulic head, and groundwater velocity data; determine hydraulic connection/- gradients between bedrock and overburden
21D	South of South Pond; Southeast of Well clusters MW-7 and MW-14	Define southeastern (downgradient) extent of contamination plume detected in Well Cluster 14	Provide fracture, hydraulic head and velocity data from downgradient location; determine hydraulic connection between bedrock and overburden

- Split-spoon samples will be taken during the installation of the six monitoring wells in the overburden. The screened intervals will be determined based upon the lithologies observed from the samples.

- NX core will be taken from the four bedrock wells for the purpose of determining the distribution of fractures and confirming the stratigraphic and lithologic interpretations from the EERU Well Installation Report.

- Borehole geophysical logging in the bedrock wells will be performed by the U.S.G.S. for the purpose of determining the distribution and extent of fractures. The types of logging techniques to be used are discussed in Section 5.3.7.

- Packer tests will be performed in the bedrock wells for the purpose of determining the hydraulic properties of the bedrock. The position of the packers will be determined based upon the observations of the core, and upon the results of the geophysical logging. Multiple test may be performed in a single well, depending on the distribution of fractures present.

- Well completion of the bedrock wells will be performed by reaming the core holes after the packer tests have been conducted. The screened intervals will be determined based upon the core, geophysical logs, and packer tests, and tracer test results. Well development will occur at least 24 hours after installation.

- Water levels will be measured to obtain additional information concerning the piezometric head distribution in the overburden and bedrock. Water levels in existing wells will also be measured. At least two additional rounds of water-level measurements will be collected. Ideally one of these will document short-term response to precipitation events.

- Groundwater sampling will be performed at a specified length of time after well completion (at least one week). Sampling will serve two purposes: to define the extent of contamination and background groundwater quality; and to determine the nature of the groundwater contaminant/aquifer matrix interactions.

- Slug tests or pumping tests will be conducted in all wells after stabilization from purging for the sampling. The objective of these tests is to provide location specific measurements of hydraulic properties of the screened interval and, for the longer term pumping tests, a measurement of aquifer parameters in the vicinity of the well. This information will be particularly useful in the future evaluation of remedial technologies involving groundwater extraction.

- Tracer-tests will be performed by the U.S.G.S. according to the methodology given in Section 5.3.7. The wells chosen for the tracer tests will be based upon the results of the slug and/or pumping tests. the tests will be used to determine the hydraulic interconnection and groundwater travel time along fracture zones.

Additional information regarding the conduct of these groundwater-related field tasks is provided in Section 5.3. Data evaluation is discussed in Section 5.5.

Surface water and sediment samples will be collected from Lagoons 4 and 5, and from both upgradient and downgradient locations in the west stream. Surface water samples only will be collected from the east and south ponds. Analysis of these samples will provide the necessary data to assess the risk associated with potential exposures to these media as well as the need for some type of remediation. Samples will also be collected from two groundwater discharge seeps (i.e., springs) that have been observed at the site. The locations of these seeps are shown on Figure 5-2. Analysis of seep samples will yield information concerning the quality of shallow groundwater discharging at the site.

4.3 OPERABLE UNIT 3

Existing soils data are limited to surface and near-surface samples from the locations shown in Figure 2-5. The majority of these samples were collected by REM III or EPA-TAT in the lagoon, drum handling/disposal, and backfill areas. These samples established the presence of surface and shallow subsurface soil contamination but did not define the vertical extent of contamination (i.e., below 10 feet) in these areas. Additional soil borings in these source areas will be necessary to define subsurface contamination.

Samples were also collected and analyzed from selected ERB/EERU monitoring well borings (2S, 2D, 3, 4 and 10). Although these samples were reported as "clean," the validity of the data has not been determined. In addition, four of the five sampling locations were along a 250-foot long stretch of the site access road (next to the Drum Disposal Area); the other location was to the northeast (and probably upgradient) of Lagoon 1. Consequently, the EERU data are of limited value in evaluating either the areal or vertical extent of contamination in these areas on the Greenwood Chemical Site.

The technical approach developed for Operable Unit 3 (soils) is designed to complete the physical and chemical characterization of surface and subsurface soils begun during the removal and interim remedial activities. The objectives of the proposed field investigation for this OU are to obtain geotechnical, geochemical, and contamination data needed to evaluate public health/environmental risks and any appropriate remedial alternatives.

Data gaps were identified in three primary areas: extent of contamination, soil/contaminant interactions, and background soil concentrations. Specific data gaps to be resolved by the proposed remedial investigation include the following:

- o Vertical extent of contamination in the unsaturated zone beneath primary source areas (Lagoons, backfill and drum handling areas);
- o Areal extent of contamination in downgradient areas;
- o Existence of hot spots and overall distribution of contamination within backfill and underlying soils of the former buried drum area;
- o Additional background soils data, particularly at depth within the unsaturated zone;
- o Soil attenuation capacity associated with adsorption and ion exchange reactions;
- o Estimates of in-situ contaminant mobility;
- o Geotechnical data including permeability, density and grain size.

Eleven (11) soil borings and ten (10) auger borings are planned to provide either samples or a means of direct measurement/observation to obtain the necessary data. The boring locations are shown on Figure 5-1.

Soil borings will be drilled to an average depth of 14 feet, with sampling limited to the collection of six (6) split-spoon samples per boring. The actual depth to be drilled in an individual soil boring will vary depending on the location and conditions encountered. Borings will be advanced to the water table when feasible (i.e., where the water table is at shallow depths). Elsewhere, the boring will terminate at a depth selected by the rig geologist and FOL.

Auger borings will be drilled to an average depth of 10 feet. All but one will be in the former buried drum area. One auger boring will be drilled near the sump in the Drum Handling One area. Sampling in this boring will be at the discretion of the FOL. Auger boring sampling in the former buried drum area will focus on the interval immediately below the contact between natural soil and backfill materials (see below). The number of samples per auger boring is expected to vary between two and four. All sampling will be accomplished with a split-spoon.

The primary objective of the soil borings in the lagoon areas is to determine the extent of vertical migration downward through the unsaturated zone. Two soil borings will be drilled in the former Lagoon 1 area. Following sludge removal, shallow soil samples taken from two locations within the lagoon were found to contain the highest levels of soil contamination onsite. Two borings are planned because of the significant variability detected at the two previous sampling locations. Only one boring is planned for the former Lagoon 2 area due to the similarities in contamination detected among soil samples from different locations within the lagoon. Borings are not planned for the former Lagoon 3 area due to a general absence of contamination in the previous samples collected at this location.

Former Buried Drum Area

Four (4) soil borings and nine (9) auger borings will be drilled in the area formerly used for buried drum disposal. A large number of borings is planned due to the potential for significant soil contamination and the size of the area of concern. An investigative approach for locating potential "hot spots" and assessing the overall extent of contamination in this area was developed using geostatistical methods contained in Gilbert (1987). This methodology relies on assumptions concerning the size and existence of hot spots ("targets").

The basic assumptions are as follows: There is considerable evidence, based on previous reports and observations during removal activities, that one or more hot spots are likely to exist in the former buried drum area (i.e., the "a priori" evidence is strong). In order to be 95% confident (other confidence levels could also be specified) of detecting such a hot spot, located at/below the backfill-soil interface, it was determined that a triangular grid with 50 foot spacing would be needed. This configuration yields a 95% confidence of detecting a circular hot spot of radius 24 feet. Conversely, given the a priori evidence for a hot spot in this area, if such a sampling grid were used and no hot spot were detected, there would be only a 5% chance that such a hot spot actually exists. A larger or smaller hot spot would result in an increase or decrease, respectively, in the confidence level for the investigation. Details concerning this methodology are summarized in Table 4-4.

The four (4) soil borings in the former buried drum area will be drilled to an average depth of 14 feet. Six (6) split-spoon samples will be collected from each boring; four of these will be retained for laboratory analysis. Depending on the conditions encountered, one or two of the samples analyzed will be backfill material; the remainder will be from the interface or below. Samples will be collected according to the screening criteria identified in Table 4-5. Selected samples will then be sent for laboratory analysis. An additional, optional soil boring (B12) may be drilled in this area based on the review of the EPA Removal Action report currently in preparation. Actual locations of the other four borings also may vary as a result of this input.

Auger borings in the former buried drum area will be advanced without sampling to a depth 2-3 feet above the natural soil-backfill interface. Two to four samples will be taken at each location, with the intent of obtaining soil/backfill materials at the interface and natural soil from below. Details concerning the soil sampling and analysis plan are given in Table 4-3.

Waste Dump, Drum Handling and Backfill Areas

A single boring is planned for each of the nine (9) remaining source areas and potential source areas as follows:

- o Backfill North
- o Backfill Northeast
- o East Drums
- o Drum Handling Area 1 Sump (Auger Boring)
- o Waste Dump
- o Northern Warehouse (opticnal)
- o Buildings A, B, and C (one each)

Surface and near-surface contamination was detected in most of these areas. The objective of the planned boring program is to determine the full extent of downward migration from these shallow zones toward the water table. The decision to complete the optional soil borings at the Northern Warehouse will be on the basis of test pit observations in that area.

In addition, shallow test pits are planned to investigate subsurface and near-surface contamination at two locations where spills and/or other disposal activities may have occurred. Two locations have been identified: near the southern warehouse (north of the Process building) and adjacent to the sump in the Drum Handling Area 3. A third test pit may be excavated in a potential spill area at the discretion of the FOL. Soil samples from these test pits will be collected, also at the discretion of the FOL.

Surface soil samples (0 to 1.5 feet) will also be collected in the drum handling and process building areas. Surface sampling locations (not to exceed three) will be selected on the basis of visual observation or other data suggesting possible spills, discharge or disposal of waste materials.

TABLE 4-3
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
OPERABLE UNIT 3 (SOILS)
SOIL SAMPLING LOCATIONS

SAMPLING LOCATIONS	SITE REFERENCE	ESTIMATED NUMBER OF SAMPLES TO PASS SCREENING[1]	NUMBER & TYPES OF ANALYSES[2]	RATIONALE
B13 (Optional) Monitoring Well Boring 17S	East of North Warehouse	2	(2) TCL Org & Inorg (1) Pesticide & PCB (1) Geotech Parameters	Investigate possible soil contamination associated with tanks and other chemical/process related activities at this location (identified on aerial photograph)
TP7	Near storage trailers and South Warehouse (North of Process Buildings)	1	(2) TCL Org & Inorg	Investigate possible soil contamination associated with product and/or waste handling/storage areas; if clean, may be used as upgradient (background) data as well
B1	Drum Area East	3	(3) TCL Org & Inorg	Determine vertical extent of contamination in this area
AB10	Adjacent to Sump Immediately South of Building C	2	(2) TCL Org & Inorg	Determine vertical extent of contamination next to sump that received waste flows from process buildings
TP8	Portion of Drum Handling Three and Adjacent to Outdoor Platform	2	(2) TCL Org & Inorg	Investigate subsurface contamination adjacent to process area and within this drum handling area
B2, B4	Backfill Northeast and Backfill North	10	(7) TCL Organics (4) Pesticides & PCBs (10) TCL Inorganics (2) F & D Cyanide (4) Arsenate/Arsenite (2) Geotech Parameters	Determine vertical extent of contamination in these former lagoons

TABLE 4-3 (Continued)
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
OPERABLE UNIT 3 (SOILS)
SOIL BORINGS

SOIL BORINGS	LOCATION	ESTIMATED NUMBER OF SAMPLES TO PASS SCREENING[1]	NUMBER & TYPES OF ANALYSES	RATIONALE
B3	Waste Dump Area	2	(2) TCL Org & Inorg (1) Geotech Parameters	Determine vertical extent of contamination in waste disposal area along drainage pathway from drum handling & process areas
B5, B6, B7	Former Lagoons 1 & 2	15	(15) TCL Org & Inorg (4) F & D Cyanide (4) Arsenate/Arsenite (2) Geotech Parameters	Determine vertical extent of contamination in natural soils beneath partially remediated lagoons. Two borings are required in the former Lagoon 1 area because of the high variability of results of previous sampling.
B8, B9, B10, B11	Drum Disposal Area	16	(16) TCL Org & Inorg (2) Geotech Parameters	Determine vertical extent of contamination in natural soils beneath drum disposal area. Determine extent of contamination in backfill materials.
AB1 thru AB9 (Auger borings)	Former Drum Disposal Area	20	(20) TCL Org & Inorg	Determine extent of contamination beneath the backfill at the Former Drum Disposal Area

NOTE: (1) Screening criteria are shown in Table 4-5

TABLE 4-4
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
DRUM DISPOSAL AREA-STATISTICAL SAMPLING RATIONALE

GRID SIZE[1]	HOT SPOT TARGET RADIUS[2]	NUMBER OF SAMPLES[3]
25 ft	12 ft	26
50 ft	24 ft	13
100 ft	48 ft	8

ASSUMPTIONS:

A. There is considerable a priori evidence that a "hot spot" target (i.e., zone of contamination) exists in the former drum disposal area, (75% probability of contamination assumed)

B. A certainty-of-detection confidence level of 95% was assumed (i.e., with given grid spacings, there will be at least a 95% chance of finding a hot spot of minimum target radii shown above)

Notes:

1. A triangular grid is employed.
2. Target is assumed to be circular.
3. Number of samples is based on estimated areal extent of former drum disposal area.

Reference: Gilbert, R.O., 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold Company, New York.

TABLE 4-5
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
PRE-SCREENING CRITERIA FOR SOIL SAMPLES FROM BORINGS

SAMPLING INTERVAL	CRITERIA
SURFACE	o Along drainage pathways from potential source areas
	o Above background reading on HNU
	o Distance to previous surface sampling location > 100 ft
UNSATURATED ZONE	o High reading (using HNU) of all unsaturated soil samples within a boring
	o Unusual staining, discoloration and/or presence of buried debris
	o Representative sample of the uppermost "confining" layer (i.e., shallowest fine-grained layer with potential to restrict downward percolation of liquids)
WATER TABLE INTERFACE	o Samples from the water table interface will be retained for laboratory analysis.

A single floor boring is planned in each of the three main process buildings to investigate possible contamination resulting from migration through cracks in the floor slab, leaking floor drains or other pathways. These borings will extend 2 to 4 feet beneath the slabs, conditions permitting. A single split-spoon or hand auger sample representative of the fill or natural soil material beneath the slab will be retained for analysis.

Downgradient Areas

Soil contamination data from areas downgradient of the source areas will be collected from surface soil sampling locations along drainage pathways. The precise number and locations of these samples (not to exceed five) will be at the discretion of the FOL.

4.4 OPERABLE UNIT 4

The magnetometer survey of the Greenwood Chemical Site, conducted in September 1987, indicated at least six anomalies that were not related to steel-reinforced concrete buildings and slabs, machinery, or other surface debris. These anomaly locations may be related to buried structures, tanks or other metallic debris. In order to determine the cause of the magnetic anomalies and to confirm the presence/absence of contaminated soil, a trench will be dug at each location by a backhoe. The trench geology will be logged and the excavated material visually inspected. Selected samples for chemical analyses may be obtained from the backhoe bucket and sent for TCL analyses. This sampling will be at the discretion of the Field Operations Leader. Results will be correlated with information from the other three operable units.

4.5 DATA QUALITY OBJECTIVE (DQO) DETERMINATION

A general discussion of the Data Quality Objectives identified for the Greenwood Chemical Site is found in the March 1988 Field Operation Plan, the Task 14 document, and earlier reports. For this Work Plan, the discussion focuses on the specific level of data quality needed to meet the RI/FS and FFS objectives for each of the operable units.

Data quality is a measure of the degree of uncertainty in the data with respect to precision, accuracy, representativeness, comparability, and completeness associated with specific analytical methodologies. The five level analytical approach applicable to achieving the goals of a project is defined as follows:

1) <u>Screening</u> (Level 1): This provides the lowest data quality but the most rapid results. It is often used for health and safety monitoring at the site, preliminary comparison to ARARs, initial site characterization to locate areas for subsequent and more accurate analyses, and for engineering screening of alternatives (bench-scale tests). These types of data include those generated on-site through the use of HNU, pH, conductivity, and other real-time monitoring equipment.

2) <u>Field Analyses</u> (Level 2): This provides rapid results and better quality than in Level 1.

3) <u>Engineering</u> (Level 3): This provides an intermediate level of data quality and is used for site characterization. Engineering analyses may include mobile-lab generated data but generally refer to Standard EPA analytical lab methods without the degree of QA/QC provided by CLP analyses.

4) <u>Confirmational</u> (Level 4): This provides the highest level of data quality and is used for purposes of risk assessment, engineering design, and cost recovery documentation. These analyses require full CLP analytical and data validation procedures.

5) <u>Non-Standard</u> (Level 5): This refers to analyses by non-standard protocols, for example, when exacting detection limits, or analysis of an unusual chemical compound. These analyses often require method development or adaptation.

At the Greenwood Chemical Site, pH and conductivity measurements will be performed to Level 1. The geotechnical analyses (including laboratory permeability, grain size analyses, bulk densities and moisture content determinations) will be performed to Level 2. Field screening also will provide Level 2 data. All other chemical analyses of environmental media will be performed to either Level 3 or Level 4, depending on the types of analyses, sample location, and intended use of data as explained below.

To reduce both cost and time requirements for laboratory analyses and data validation, Level 3 data will be utilized to the maximum extent practicable. A substantial quantity of Level 4 data exists for the soil, groundwater, surface water and sediment at the site. Because a large proportion of the proposed sampling and analysis program will be used for extent of contamination determinations and/or engineering purposes, the requirements for Level 4 data (needed primarily for confirmational risk assessment purposes) are greatly reduced.

For the following samples, all laboratory chemical analyses will be performed to Level 4:

- Soil: All soil samples selected for arsenate/arsenite and free and dissociable cyanide analyses.
- Groundwater: All residential well samples and the samples from the newly installed site monitoring wells and all samples selected for free and dissociable cyanide.

Using these criteria approximately 20% of the soil samples and 35% of the groundwater samples will require Level 4 methods.

Table 5-1 lists the expected DQO levels for the entire sampling and analysis plan. Lowered detection limit analysis may be required for phenol and several inorganic compounds in order to compare groundwater concentrations with Virginia State standards.

5.0 TASK PLAN FOR REMEDIAL INVESTIGATION

5.1 TASK 1 - PROJECT PLANNING

Task 1 consists of the preparation of the Work Plan and Field Operations Plan (FOP). The FOP contains three major sections: the Field Sampling and Analysis Plan (FSAP), the Site Management Plan (SMP), and site Health and Safety Plan (HASP). For the Greenwood Chemical Site these documents contain the combined plans for conducting work on the four defined operable units.

- Work Plan: The Greenwood Chemical Site Work Plan defines the objectives of the RI/FS and FFS for each operable unit and describes the specific tasks to be performed to meet these objectives. The Work Plan also provides a summary of past activities on-site and gives the technical approach and rationale for each work item proposed.

- Field Sampling and Analysis Plan (FSAP): The Sampling and Analysis Plan will be developed based on the data quality objectives required for each media sampled. The plan will include the number, type, and location of all samples to be collected. The site-specific quality assurance requirements will be in accordance with the Quality Assurance Project Plan for the REM III program and the procedures used will follow the REM III Field Technical Guidelines. The sampling equipment, sample custody and handling, and the analyses to be conducted will all be described in the FSAP.

- Site Management Plan (SMP): The Site Management Plan includes a brief site description, an operations plan outlining the site project organizations and responsibilities and the field operations schedule. The SMP also addresses site security.

- Health and Safety Plan (HASP): The site specific Health and Safety Plan will be developed using results of previous site investigations. The HASP will include personal protective equipment (PPE) requirements, contingency plan and emergency procedures, a safety monitoring program, decontamination procedures and other requirements according to the REM III Health and Safety Plan. The Greenwood Chemical Site HASP will apply to sampling and other site activities for all four operable units.

5.2 TASK 2 - COMMUNITY RELATIONS

REM III Community Relations (CR) staff will assist EPA in implementing the Community Relations Plan for the Greenwood Chemical Site. This assistance will be provided as specifically requested by EPA. REM III participation is expected to include the following activities which are divided to mirror the remedial phases currently planned for the Greenwood Chemical Site.

RI/FS Activities (OU2, 3 and 4)

- Revise the existing draft CRP to reflect changes that have occurred since the draft was issued.

- Prepare a Proposed Plan coinciding with the release of the RI/FS Report. The plan will discuss the remedial alternatives presented in the RI/FS Report as well as the EPA's preferred alternative and rationale for this preference. The plan will also actively solicit public review and public comment regarding the remedial alternatives under consideration.

- Prepare a Public Notice to announce the availability of the RI/FS Report and the Proposed Plan at the local information repository and to advise the community of the public comment period. The notice will appear as a display ad in at least one local newspaper and will outline major findings and recommendations of the RI/FS Report.

- Provide Public Meeting Support by coordinating services such as drafting, graphics, and public stenography,, and by securing a meeting location. REM III CR staff will also attend the meeting and prepare a meeting summary.

- Prepare a Responsiveness Summary. This document will be based on the official transcript of the public meeting and on any additional comments received by EPA during the comment period. The document will summarize the major comments and concerns expressed by the public and the EPA's responses.

FFS Activities (OU1) - Task 16

The activities that are anticipated during the FFS can be defined by referring to the corresponding task descriptions listed above. They differ only in that they are concerned specifically with the Record of Decision for Operable Unit 1 (the FFS).

- Prepare a Proposed Plan
- Prepare a Public Notice
- Provide Public Meeting Support
- Prepare a Responsiveness Summary

5.3 TASK 3 - FIELD INVESTIGATION

This task includes all efforts related to implementing the field investigation for the four currently defined operable units at the site. The objectives of the field investigation are as follows:

Operable Unit I - Containers, Sludge and Lagoon Soils

1) Confirm the June 1988 drum and container inventory, proposed usages by the Greenwood Chemical Company, and verify the locations of drums to be removed.

2) Characterize the physical/chemical properties of the sludge/kiln dust mixture, sludge, and contaminated soils as needed to evaluate appropriate remedial alternatives.

3) Refine estimates of the volume of materials to be addressed via remedial action.

Operable Unit II - Groundwater

1) Determine the extent and magnitude of contaminated groundwater in the saprolite (overburden) and fractured bedrock.

2) Confirm the influence of bedrock fractures on the direction of groundwater flow and distribution of contaminants.

3) Define the recharge/discharge relationships between surface water and groundwater.

4) Determine the hydraulic interconnection between bedrock and overburden.

5) Confirm the presence/absence of site-related contamination in private or public water wells adjacent to and downgradient from the site.

6) Collect sufficient physical characterization data to support groundwater flow and transport modeling.

7) Confirm the presence/absence of site related contaminants in West Stream and other surface water sources near the site.

Operable Unit III - Soil

1) Determine the nature and extent of surface and subsurface soil contamination in downgradient and peripheral areas.

2) Determine the vertical extent of contamination for soil in the unsaturated zone beneath the source areas (lagoons, backfill and drum handling areas).

3) Identify the location of hot spots and the overall distribution of contamination in the natural soil and backfill materials beneath the former buried drum area.

4) Characterize the physical/chemical properties of selected soil samples for remedial alternative screening and evaluation.

5) Estimate the natural attenuation capacity of site soils for the major contaminants of concern.

Operable Unit IV - Underground Structures

1) Investigate the source of magnetic anomalies measured at six on-site locations.

2) Confirm the presence/absence of soil contamination in the upper 10 feet of soil at these six locations.

The field investigation will consist of 11 subtasks, details concerning the conduct of each of these subtasks are presented in the following discussions.

5.3.1 Subcontracting/Procurement

Bid specifications will be prepared and subcontractors procured for topographic surveying and drilling services. Topographic surveying services will include revising the existing site base map to reflect changes to surface topography caused by removal action and determining the location and elevation of soil and groundwater sampling points. Drilling services will include decontamination pad construction, subsurface soil sampling, rock coring/reaming, packer tests, installation of monitoring wells, well development and test pit excavation.

5.3.2 Mobilization/Demobilization

This subtask will include the mobilization of field personnel and equipment to the site. During mobilization an orientation meeting of all field personnel will be held to review site history and layout, health and safety training, and field procedures.

Equipment mobilization will include the following:

- o Field trailer (command post);
- o Drilling equipment;
- o Sampling equipment;
- o Equipment decontamination materials; and
- o Health and safety equipment.

Telephone and electrical service will be obtained along with a local water source. All companies (i.e., pipeline, gas, electric, water, and telephone) suspected of having underground lines on site or in the immediate vicinity of the site will be contacted prior to the start of the investigation. Any underground utilities will be staked and flagged for the duration of the investigation.

5.3.3 Drum/Container Inventory for OU1

The current inventory of drums/containers for which Greenwood Chemical Company has not defined an intended use or interest in retaining will be confirmed by visual inspection of drums and labels. In addition, miscellaneous metal tanks and containers outside of the buildings and near the lagoons which have not been addressed to date will be inspected and inventoried.

It will be assumed for the FFS that the building structures themselves do not pose a threat to human health or the environment.

5.3.4 Soil Sampling for OU1, OU3 and OU4

In order to fulfill the risk assessment and remedial alternatives evaluation objectives for OU's 1 and 3 identified in Section 4.0, surface and subsurface soil samples will be collected and analyzed for both physical and chemical parameters. Sampling activities will focus on potential source characterization in the process and waste disposal areas; however, data concerning the extent of contamination in downgradient as well as peripheral areas will also be obtained. A summary of the proposed soil sampling program is presented in Table 4-3. The table also presents the rationale used in choosing locations for the soil and auger borings and test pits (OU3 test pits only).

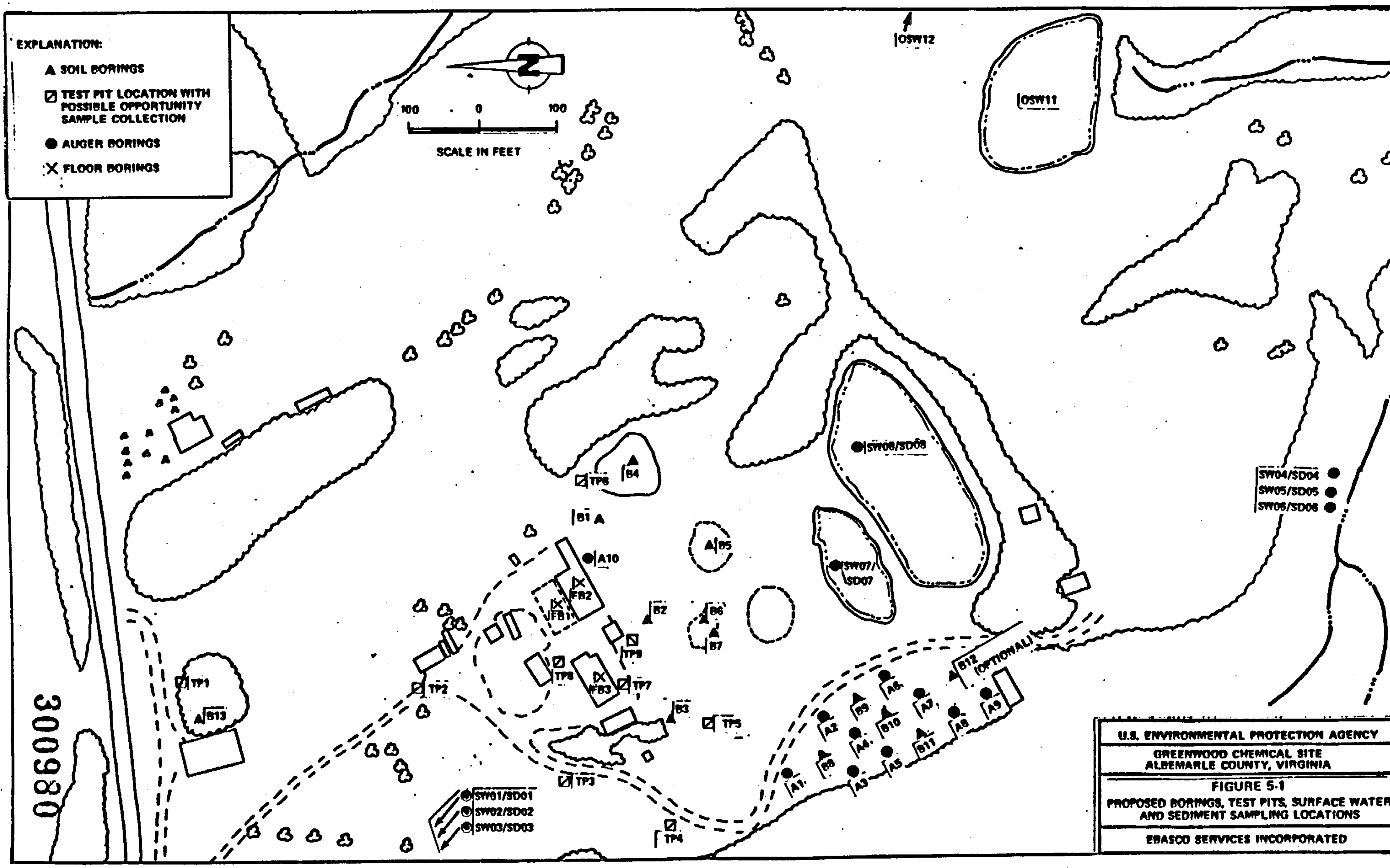
Sampling in support of the OU1 FFS will consist of limited surface/near-surface sampling in the former Lagoon 1, 2, and 3 areas and in the Backfill North Area. Sampling locations are shown in Figure 5-2. Excavations will extend into the natural soil horizon formerly underlying lagoon sludges (in Lagoon 1 and 2), into the buried sludge layer (Backfill North), or into the encapsulated sludge/kiln dust (Lagoon 3/Vault). The objective of this sampling is to collect representative sludge and/or highly contaminated soil samples for waste characterization analyses. Samples will be collected with a hand-auger, split-spoon or other methods approved by the FOL. If necessary, deeper samples may be taken using a backhoe. Procedural details concerning OU1 sampling are contained in the Field Operations Plan.

For OU3, surface and subsurface soil sampling will be completed at the 11 soil boring locations shown in Figure 5-1. Data from these samples will also support the OU1 FFS, primarily in refining waste volume estimates for former lagoons and backfill areas (due to projected data analysis and validation schedules, however, these data are not expected to be available until late in the FFS development process). Soil samples will also be collected from up to five surface sampling locations on-site. These locations will include both probable spill areas in the vicinity of the process buildings as well as downgradient, extent-of-contamination locations along surface drainage pathways. In addition, 9 auger borings will be drilled in the Drum Disposal Area to obtain soil samples from the interval at/below the natural soil-backfill contact. A tenth auger boring is planned to investigate subsurface contamination near the Drum Handling Area 1 sump. Three (3) test pits are planned, also in areas of suspected spills and/or disposal activities. A breakdown of the estimated soil sampling and analyses associated with the soil boring, auger boring test pit, and surface soil sampling program is presented in Table 5-1.

To satisfy risk assessment data gaps, three surface soil samples will be collected from pastureland adjacent to the site. In addition, one soil (or fill) sample will be obtained from beneath each of three three main process building adjacent to floor drains.

Soil samples collected in the soil and auger borings and test pits will be screened in the field using the criteria listed in Table 4-5. Depending on the results of this screening, a statistically representative number of samples will be sent to the laboratory for TCL, SAS, and/or specialized geochemical and geotechnical analyses.

Soil sampling in support of OU4 will consist of three opportunity samples to be collected at the discretion of the Field Operations Leader. These samples will be collected during test pit excavation activities where necessary.



U.S. ENVIRONMENTAL PROTECTION AGENCY

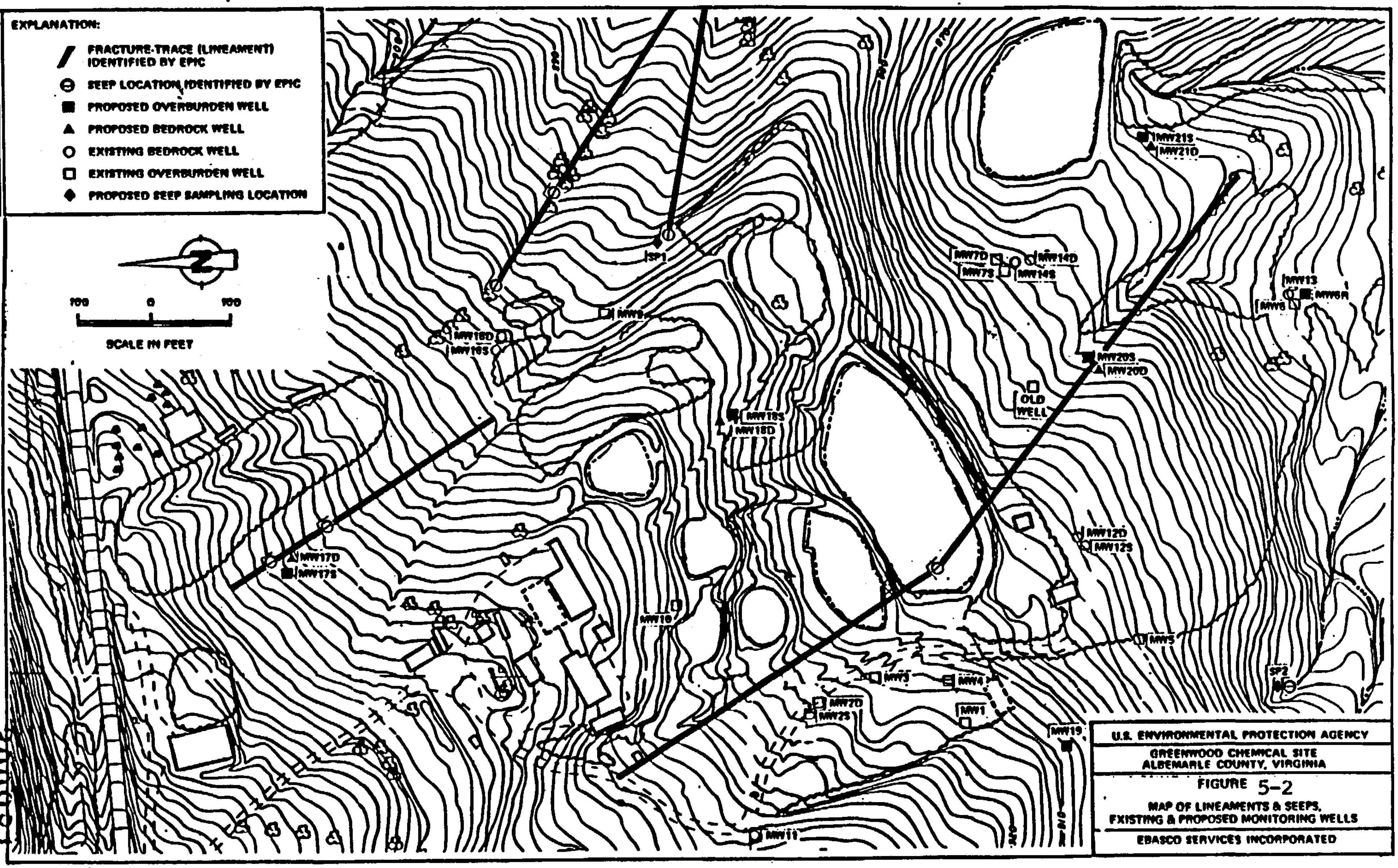
GREENWOOD CHEMICAL SITE
ALBEMARLE COUNTY, VIRGINIA

FIGURE 5-1

PROPOSED BORINGS, TEST PITS, SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

EBASCO SERVICES INCORPORATED

300980



U.S. ENVIRONMENTAL PROTECTION AGENCY

GREENWOOD CHEMICAL SITE
ALBEMARLE COUNTY, VIRGINIA

FIGURE 5-2

MAP OF LINEAMENTS & SEEPS, EXISTING & PROPOSED MONITORING WELLS

EBASCO SERVICES INCORPORATED

TABLE 5-1
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
SAMPLING AND ANALYSIS - AQUEOUS MATRIX

			STANDARD TCL					SPECIAL ANALYSES			FIELD ANALYSES[3]					
GROUNDWATER	# OF WELLS	NUMBER OF SAMPLES COLLECTED	VOLATILES	SEMI-VOLATILES	INORGANIC NON-FLTRD	INORGANIC FILTERED	PCB/ PEST	F&D CN^-	LOW DETECT. CN^-	ANIONS[2]	pH	SPEC COND	DO	TEMP	DQO LEVEL IV	DQO LEVEL III
Existing Wells																
Bedrock	8	8	8	8	8	8	--	1	8	8	8	8	8	8	1	7
Overburden	11	11	11	11	11	11	--	1	11	11	11	11	11	11	1	10
Ebasco Wells																
Bedrock	4	4	4	4	4	4	1	2	4	4	4	4	4	4	4	--
Overburden (inc. optional well)	6	6	6	6	6	6	1	2	6	6	6	6	6	6	6	--
Residential Wells	5	5	5	5	5	--	--	5	5	--	5	5	5	5	5	--
Surface Water																
Ponds (2)	--	2	2	2	2	--	--	--	--	--	2	2	2	2	--	2
Lagoons 4 & 5	--	2	2	2	2	--	--	--	--	--	2	2	2	2	--	2
Seeps (2)	--	2	2	2	2	--	--	--	--	--	2	2	2	2	--	2
West Stream	--	6	6	6	6	--	--	--	--	--	6	6	6	6	--	6
Sub Totals	34	46	46	46	46	39	2	11	34	29	46	46	46	46	17	29
Field Duplicates	--	3	3	3	3	2	1	1	2	1	--	--	--	--	1	2
Field Blanks	--	3	3	3	3	2	1	1	2	1	--	--	--	--	1	2
Rinsate Blanks	--	3	3	3	3	2	1	1	2	1	--	--	--	--	1	2
Trip Blanks (4)	--	15	15	--	--	--	--	--	--	--	--	--	--	--	5	10
TOTALS	34	70	70	55	55	45	5	14	40	32	46	46	46	46	25	45

NOTES:

1) Includes cations (NA^+, Mg^{2+}, Ca^{2+}, K^+)

2) Anions include Cl^-, HCO_3^-, SO_4^{2-}, CO_3^{2-}, etc.

3) Actual number of field analyses may vary.

4) Actual number of trip blanks will vary.

TABLE 5-1 (Continued)
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
SAMPLING & ANALYSIS - SOIL MATRIX

SAMPLE TYPE & LOCATION	BORINGS	# OF SAMPLES /BORING	NUMBER OF SAMPLES COLLECTED	NUMBER OF SAMPLES ANALYZED[2]	TCL VOL	TCL SV	PCB/ PEST	INORG & CN	F&D CN	ARSENATE/ ARSENITE	GEOTECHNICAL/GEOCHEMICAL PARAMETERS TOC	GRAIN SIZE	CEC	LAB K	ASTM SHAKE	WASTE CHARACT.	FIELD pH	DQO IV	DQO III
SOIL BORINGS																			
Source Areas																			
Lagoons 1 & 2	B5,B6,B7	8	24	15	15	15	--	15	4	4	2	2	2	1	2	--	2	4	11
Backfill North	B2	6	6	4	4	4	4	4	--	2	--	--	--	--	1	--	2	2	2
Backfill Northeast	B4	6	6	6	3	3	--	6	2	2	--	1	2	--	1	--	2	2	4
Waste Dump Area	B3	4	4	2	2	2	--	2	--	--	--	1	1	1	--	--	1	--	2
East Drum Area	B1	6	4	3	3	3	--	3	--	--	--	--	--	--	--	--	1	--	3
Drum Disposal Area	B8 - B11	6	24	16	16	16	--	16	--	--	2	1	1	1	--	--	5	4	12
Optional Borings	B12,B13	5	10	6	6	6	1	6	--	--	--	--	--	--	--	--	2	--	6
Beneath Bldg. Floors	BF1,BF2,BF3	1	3	3	3	3	--	3	--	--	--	--	--	--	--	--	1	3	--
AUGER BORINGS																			
Drum Disposal Area	A1 - A4	3	30	20	20	20	--	20	--	--	--	--	--	--	--	--	--	--	20
Drum Handling & Sump	A10	3	3	2	2	2	--	--	--	--	--	--	--	--	--	--	--	--	--
FFS SAMPLING																			
Lagoon 3 (Vault)	--	--	2	2	--	--	--	--	--	--	--	--	--	--	--	2	2	--	--
Lagoons 1 and 2	--	--	4	4	--	--	--	--	--	--	--	--	--	--	--	4	4	--	--
Backfill North	--	--	2	2	--	--	--	--	--	--	--	--	--	--	--	2	2	--	--
SEDIMENT																			
Stream	--	--	6	6	--	6	6	--	1	--	--	--	--	--	--	--	1	3	3
Lagoon 4 & 5	--	--	2	2	2	2	--	2	1	1	--	--	--	--	--	--	1	2	--

TABLE 5-1 (Continued)

GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN

SAMPLING & ANALYSIS - SOIL MATRIX

SAMPLE TYPE & LOCATION	NUMBER OF BORINGS	# OF SAMPLES /BORING	NUMBER OF SAMPLES COLLECTED	NUMBER OF SAMPLES ANALYZED	TCL VOL	TCL SV	PCB/ PEST	INORG & CN	F&D CN	ARSENATE/ ARSENITE	GEOTECHNICAL/GEOCHEMICAL PARAMETERS TOC	GRAIN SIZE	CEC	LAB K	ASTM SHAKE	WASTE CHARACT.	FIELD pH	DOO IV	DOO III
SURFACE SOIL	--	--	8	8	8	8	--	8	--	--	--	--	--	--	--	--	2	--	3
OU3 and OU4 TEST PITS	--	--	9	6	6	6	--	6	--	--	--	--	--	--	1	--	2	--	6
(optional samples)																			
SUBTOTALS	--	--	139	117	90	96	11	91	8	9	4	5	6	3	5	8	30	20	72
FIELD DUPLICATES	--	--	6	6(4)	5	5	1	5	1	1	--	--	--	--	1	--	5	1	4
RINSATE BLANKS	--	--	6	6(4)	5	5	1	5	1	1	--	--	--	--	--	--	--	1	4
TRIP BLANKS (4)	--	--	15	15	15	--	--	--	--	--	--	--	--	--	--	--	--	5	10
TOTALS			166	144	115	106	13	101	10	11	4	5	6	3	6	8	35	27	90

Notes: (2) Estimates only; field screening techniques may result in more or less samples being shipped to laboratory.
(3) All samples analyzed
(4) Actual number may vary

5.3.5 Surface Water/Sediment Sampling for OU2

One surface water and sediment sample will be obtained from the inlet area of Lagoon 4 and one from the inlet area of Lagoon 5. In addition, three upgradient and three downgradient surface water and sediment samples will be obtained from the West Stream to support the risk assessment. A single surface water sample will also be collected from each of the ponds adjacent to the site (i.e., the south and east ponds). Surface water and sediment sampling locations are shown on Figure 5-1.

5.3.6 Monitoring Well Drilling and Installation

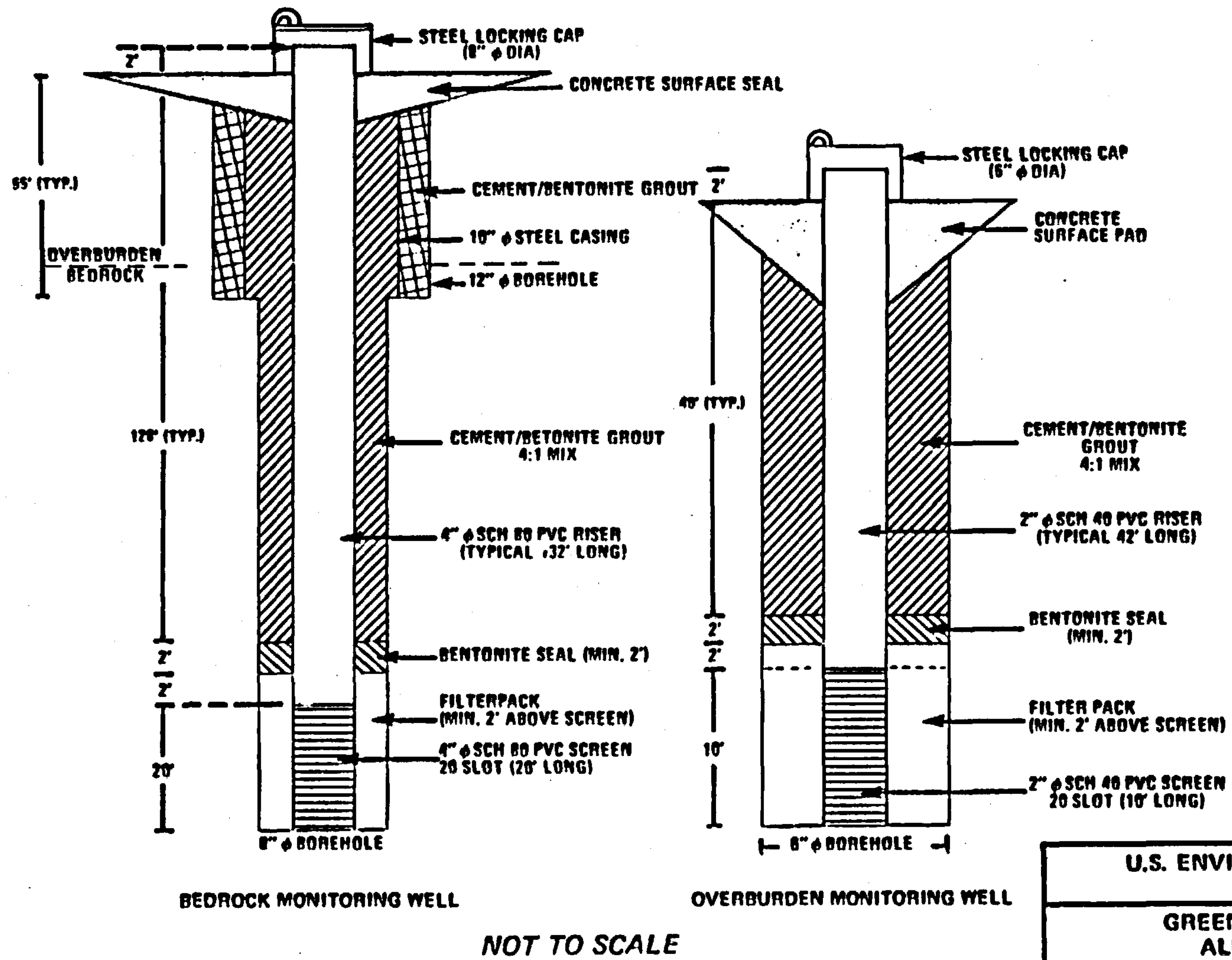
The locations of proposed wells are shown on Figure 5-3. Overburden wells will be drilled to six inches diameter. It is expected that subsurface conditions will be conductive to drilling by hollow stem auger, although it is possible that rotary drilling might be necessary. Overburden wells will have 3-inch split spoon samples taken continuously from the surface to the water table, and at 5-foot intervals thereafter to the total depth of the well. Bedrock wells 17, 18, and 20 will not have soil samples taken because each of them are one well of a well pair, and their counterpart overburden well will have soil samples taken throughout the entire thickness of the overburden. Overburden wells will be completed with 2-inch diameter PVC casing and 10-foot screen with a PVC end plug. Figure 5-4 illustrates well construction details for the overburden and bedrock wells.

Drilling into bedrock will be performed using NX-size wire-line rock coring techniques with a double-tube split inner-barrel sampler. The hole will be kept open through the overburden by advancing a 10-inch steel casing during drilling by either hollow stem augering of rotary drilling. The casing will be set approximately five feet into bedrock. After geophysical logging and packer testing, the bedrock holes will be reamed and completed with a 4-inch diameter PVC screen with 10 to 20 feet of screen.

5.3.7 Monitoring Well Testing

After bedrock coring (before reaming and well completion), borehole geophysical logging will be performed by the U.S.G.S. in the four bedrock wells. The logging will include caliper, temperature, and flow-meter tests.

Packers will be set in the open portion of the hole in bedrock for the purpose of performing rock pressure testing. The zones for setting the packers will be chosen based upon the examination of the rock core and upon the results of the geophysical logging.



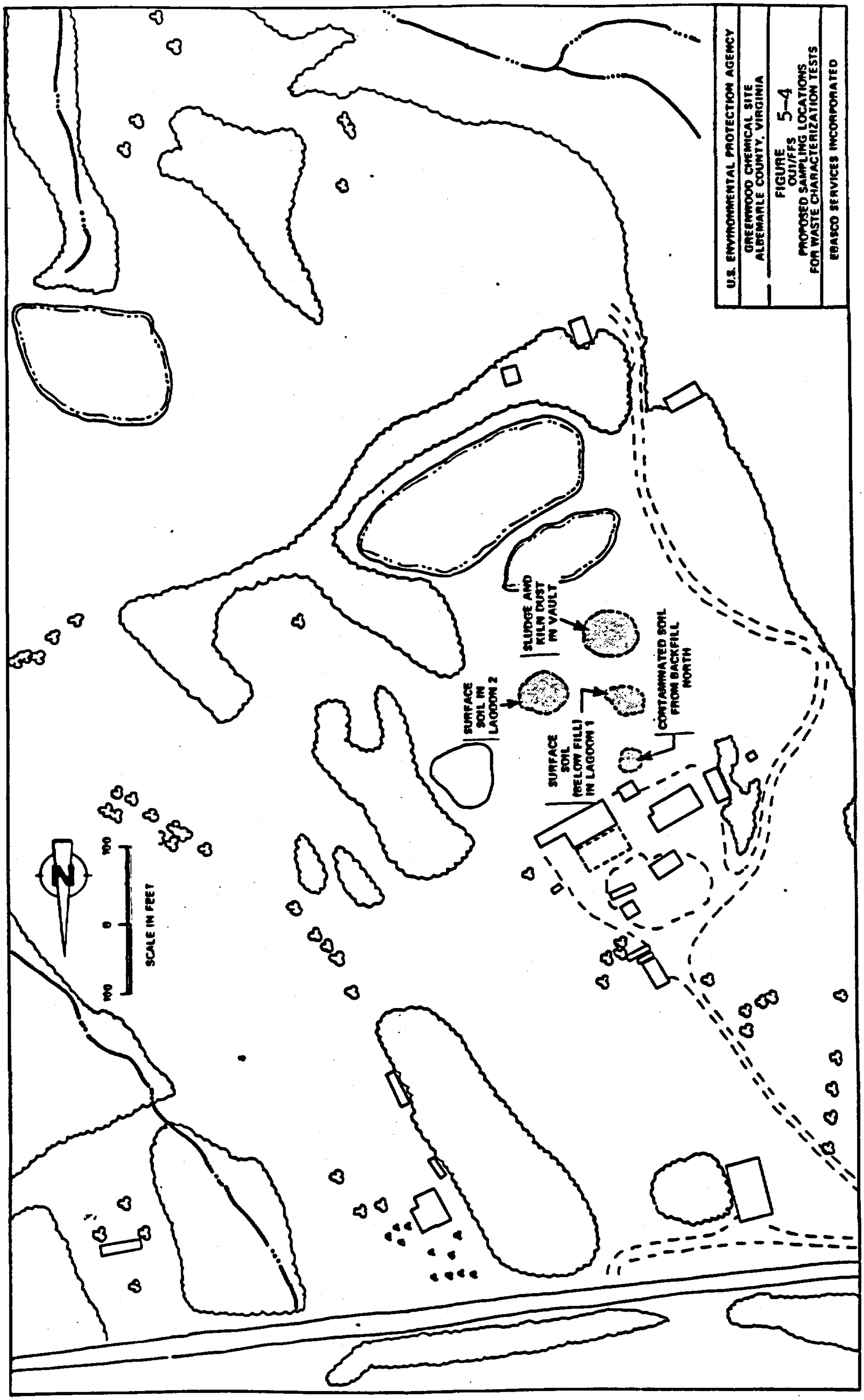
U.S. ENVIRONMENTAL PROTECTION AGENCY

GREENWOOD CHEMICAL SITE
ALBEMARLE, VIRGINIA

FIGURE 5-3

MONITOR WELL CONSTRUCTION DETAILS (TYPICAL)

EBASCO SERVICES INCORPORATED



SURFACE SOIL IN LAGOON 2
SLUDGE AND KILN DUST IN VAULT
SURFACE SOIL (BELOW FILL) IN LAGOON 1
CONTAMINATED SOIL FROM BACKFILL NORTH
N
100
0
100
SCALE IN FEET
U.S. ENVIRONMENTAL PROTECTION AGENCY
GREENWOOD CHEMICAL SITE
ALBEMARLE COUNTY, VIRGINIA
FIGURE 5-4
OU1/FFS
PROPOSED SAMPLING LOCATIONS
FOR WASTE CHARACTERIZATION TESTS
EBASCO SERVICES INCORPORATED

300987

In-situ tests will be conducted in all new wells after well completion and stabilization. The wells will first be initially tested (perhaps during well purging) for their capability to sustain a pumping rate for a 24-hour pumping test. During these tests (if any are determined possible) observations will be made in close proximity wells in the overburden and bedrock. Previously existing wells will also be used for observation of the water-level response. Slug tests will be performed in the wells which cannot sustain a pumping rate. The discharge from flowing wells in the area will also be measured.

Tracer tests will be performed by the U.S.G.S. after in-situ testing and groundwater sampling have been completed. Tracer test protocol will be at the discretion of the U.S.G.S. The specific wells chosen for this test(s) will be based upon the results of the coring as well as pumping and slug tests. At this time, single well borehole dilution tracer tests are planned. In this type of test, the tracer (expected to be a brine solution) is introduced into an isolated segment of the well and subjected to continual mixing. Groundwater flowing through the isolated well segment gradually removes the tracer from the well bore. Measurements of the change in concentration with time can be used to calculate the average horizontal velocity of the groundwater using the methodology contained in Freeze and Cherry (1979; p. 429). Multiple-well tracer tests may be conducted at a later date, if needed, to augment the single well tracer and pump test data.

Tracer tests also may be conducted in existing wells MW-7S/7D and MW14S/14D to determine the interconnection of the shallow and deep wells in both the overburden and bedrock as well as between the overburden and bedrock in adjacent boreholes.

5.3.8 Test Pit Excavation/Sampling for OU1, OU3, and OU4

Results of the magnetic survey conducted in September 1987 showed six magnetic anomalies that could not be explained by observed metal objects. As part of the OU4 investigation, a test pit or trench will be excavated with a backhoe at each of the six locations. Opportunity soil samples, taken from the backhoe bucket, may be obtained. These samples will be screened in the field and, if appropriate, analyzed for full TCL compounds at the laboratory.

Three test pits will be excavated as part of the OU3 investigation. The exact locations of these test pits will be selected on the basis of field observations or historical records (e.g., aerial photography) that indicate spills, waste disposal or related activities. All three of these test pits are expected to be located in the vicinity of the process buildings, lagoons and backfill areas.

If necessary, a shallow test trench 2-10 feet deep will be dug in the exposed bottom of Former Lagoons 1 and 2 and in the Backfill NE Area in order to obtain samples for the OU1/FFS investigation. These samples will be analyzed for selected waste characterization parameters. Collection of both sludge material and highly contaminated soils is the objective. Samples will be screened in the field for volatile organics (using an HNU or OVA) to ensure the most representative samples are sent to the laboratory.

5.3.9 Groundwater Sampling for OU2

Groundwater samples will be collected from both new and existing monitoring wells following the completion of new well installation activities. Locations of all existing and proposed wells are shown in Figure 5-3. The overall objectives of monitoring well sampling include the following:

- Determine background groundwater quality in the overburden.

- Delineate the approximate geometry of and concentration gradients within the contaminant "plumes" detected in the former buried drum area and south of Lagoon 5.

- Determine the lateral extent and variability of bedrock contamination.

- Provide water quality data to be used in evaluation of the hydrogeologic regime at the site.

Additional details concerning the monitoring well sampling and analysis program are presented in Table 5-2.

Approximately five (5) residential wells will be sampled to investigate the presence of low concentrations of cyanide detected in May 1988 sampling round. Total cyanide concentrations ranging from 12 to 14 ug/l were detected in three (3) residential well samples: the Carriage House/Estate well (14 ug/l), Fix well (12 ug/l) and J. Washington well (12 ug/l). Confirmatory analyses involving total cyanide at reduced detection limits (5 ug/l) and free and dissociate cyanide are planned. In addition, samples will be collected from 2 as-yet-to-be identified residential wells. It is anticipated that two (2) wells located to the northeast of the Simms and estate wells (Figure 2-6) will be sampled. Actual selection of these wells will be on the basis of the residential well survey to be performed under Subtask 5.3.10.

TABLE 5-2
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
GROUNDWATER SAMPLING AND ANALYSIS

MONITORING WELLS	MONITORED INTERVALS	TYPES OF ANALYSES	RATIONALE
NEW WELLS:			
17S	Overburden	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Anions/Cations Field Parameters	Groundwater in overburden untested in this area; possible contamination due to process/wasterelated activities at Northern Warehouse
17D	Bedrock	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Anions/Cations Free & Dissociable CN^- Field Parameters	Bedrock aquifer untested in this area (possibly Pedlar Formation); groundwater contamination may be present from warehouse activities; anion/cation and other water quality data to be used to define bedrock flow regime along lineament & hydraulic connection between bedrock and overburden
18S	Overburden	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Anions/Cations Field Parameters	Groundwater migration southeastward through overburden from process & backfill areas would be expected in this area; analysis of soils data from this hole will enable general estimate on in situ mobility of As and other contaminants
18D	Bedrock	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Anions/Cations Field Parameters	Determine whether contaminants are migrating southeastward from process & backfill areas; provide water quality data to be used in defining bedrock flow regime
19	Overburden	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Anions/Cations Field Parameters	Determine whether contaminants are migrating south/southwestward from buried drum disposal; provide water quality data to be used in defining overburden flow regime

TABLE 5-2 (Continued)
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
GROUNDWATER SAMPLING AND ANALYSIS

MONITORING WELLS	MONITORED INTERVAL	TYPES OF ANALYSES	RATIONALE
NEW WELLS (Cont'd)			
20S	Overburden	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Free & Dissociable CN^- Field Parameters	Establish connection (if any) between "plumes" detected in Wells 1, 3, and 4 & Well Cluster 7 and/or Well 6; water quality data will also be compared to Well 20D to evaluate hydraulic connection (recharge/discharge) along major NW-SE lineament that runs beneath lagoon area
20D	Bedrock	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Anions/Cations Free & Dissociable CN^- Field Parameters	Determine whether contamination is migrating along major NW-SE lineament that passes beneath the lagoon area & surface drainage from process & backfill areas; define western/-southwestern limits of "plume" detected in Well Cluster 14; provide water quality data for bedrock flow regime evaluation
21D	Bedrock	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Anions/Cations Field Parameters	Determine southeastern (downgradient) extent of "plume" identified in Well Cluster 14; provide water quality data to be used in defining bedrock flow regime; define recharge/discharge relationships with adjacent overburden well (21S)
21S	Overburden	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Free & Dissociable CN^- Anions/Cations Field Parameters	Determine southeastern (downgradient) extent of plume identified in Well Cluster 7; provide overburden water quality data
6R	Overburden	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Anions/Cations Field Parameters	Provide reliable groundwater quality data from properly constructed overburden well; water quality data will also be compared to Well 13 to evaluate hydraulic connection between overburden and bedrock

TABLE 5-2 (Continued)
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
GROUNDWATER SAMPLING AND ANALYSIS

MONITORING WELLS	MONITORED INTERVAL	TYPES OF ANALYSES	RATIONALE
EXISTING WELLS:			
1, 2S, 2D, 3, 4, 5, 7S, 7D, 9, 10	Overburden	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Free & Dissociable CN^- Field Parameters	Determine temporal variations in overburden groundwater quality; provide for a complete set of water quality data from both new and existing wells
11, 12S, 12D, 14S, 14D, 16S, 16D	Bedrock	TCL Organics & Inorganics Filtered Metals Low Detection CN^- Free & Dissociable CN^- Field Parameters	As above
RESIDENTIAL WELLS:			
J. Washington	Bedrock	Low Detection CN^- Free & Dissociable CN^-	Confirm presence of cyanide detected 05/88
C. Fix	Bedrock	Low Detection CN^- Free & Dissociable CN^-	Confirm presence of cyanide detected 05/88
Carriage House (Estate)	Bedrock	Low Detection CN^- Free & Dissociable CN^-	Confirm presence of cyanide detected 05/88
2 Additional Houses East/Southeast of Site (to be Determined by Well Inventory)	Bedrock	TCL Organics & Inorganics Low Detection CN^- Free & Dissociable CN^- Anions/Cations	Determine downgradient off-site groundwater quality

5.3.10 Topographic Survey/Sampling Point Locations

The topographic survey tasks include revising the existing site base map and topographic contours to account for changes in the land surface caused by the USEPA removal action. In addition, the location of soil sampling points and monitoring wells and the elevation of the monitoring wells will be obtained. The new information will be plotted on the revised base map.

5.4 TASK 4 SAMPLE ANALYSIS/VALIDATION

A summary of the analytical program for the Greenwood Chemical Site RI/FS and FFS field investigation is shown in Table 5.1. Procedural details are contained in the Field Operations Plan.

5.4.1 Sample Analyses

As summarized in Table 5-1, soil, groundwater, surface water and sediment samples will be subjected to a number of standard and non-standard analyses in the laboratory and the field. Field analyses include pH, specific conductance, temperature and dissolved oxygen for aqueous samples, and pH alone for soil samples. Standard (or routine) laboratory analyses include TCL organics, TAL inorganics, and cyanide (in soil). Analysis for the PCB/pesticide fraction is planned only for soil and groundwater samples from monitor wells near the northern warehouse and soil samples from the soil boring in the Backfill North area. A large number of non-standard analyses or special analytical services (SAS) are planned as well. These include:

- o Free and dissociable cyanide in soil and groundwater
- o Arsenate/arsenite speciation
- o Modified detection (lowered) limits for cyanide, (cadmium, mercury and phenols) in groundwater
- o ASTM Shake Test (D3987)
- o Proximate and Ultimate Analyses (incineration waste characterization)
- o Anions and cations in groundwater
- o Geotechnical analyses, total organic carbon (TOC), and cation exchange capacity (CEC)

A brief discussion of each analysis, including the objective(s) in performing the test and the intended use of test results, is presented below.

Arsenate/Arsenite

Arsenic in the natural environment generally occurs in the form of various arsenic salts, oxides and organic derivatives. Inorganic, trivalent arsenic ("arsenite") is considered to be the most toxic form of arsenic. Inorganic compounds of pentavalent arsenic ("arsenate") typically exhibit less toxicity than the prevalent forms; organic arsenic derivatives are even less toxic (ATSDR, 1987).

Analysis of the distribution of arsenite and arsenate in soil is planned to support the risk assessment as well as the development of soil cleanup concentrations and estimates regarding contaminant mobility and loading to groundwater. Use of this data in the risk assessment will enable a more accurate determination of the potential threat to public health or the environment resulting from exposures to arsenic contamination. In the calculation of soil cleanup levels, knowledge of the arsenate/arsenite ratio will enable the use of more realistic (and perhaps cost-effective) threshold concentrations in determining the need for and extent of remediation. Similarly, estimates of contaminant loading (i.e., geochemical release) to groundwater to be used in predictions regarding transport and/or natural attenuation will be enhanced through use of these relative concentration data.

Free and Dissociable Cyanide

Cyanide toxicity generally is a function of the bioavailability of the cyanide ion. In most cases, a measurement of "total cyanide" within a particular environmental medium includes both readily available or "free and dissociable" cyanide as well as cyanide that is bound up in complex organic molecules and not readily available. Measurements of total cyanide do not, therefore, provide an accurate portrayal of the true risk associated with exposure to cyanide-contaminated media.

Analysis of the relative distribution of bound vs. free and dissociable cyanide at the Greenwood Chemical Site will enable a more technically sound risk assessment to be completed. As with the arsenite/arsenate data, information concerning the distribution of free and dissociable cyanide can also be used to develop more appropriate soil cleanup levels and better estimates of contaminant loading.

Modified Detection Limits

Lowered detection limits for the groundwater contaminants cadmium, phenol, mercury and cyanide will be required in order to compare concentrations at the site with Virginia Groundwater Quality Standards. Virginia State Standards for these contaminants, as shown in Table 3-1, are below the standard CLP detection limits.

Proximate and Ultimate Analyses

Analyses of soil and sludge to determine the applicability and effectiveness of incineration (or other thermal treatment/-destruction technologies) are termed proximate and ultimate analyses. Data from these tests will be used to evaluate the feasibility of using thermal treatment technologies and to determine the operational parameters necessary to optimize such treatment. The principal use of these data will be in the FFS for OU1.

Anion/Cation Analyses

Residential and bedrock monitoring wells from the May 1988 sampling round were analyzed for anion and cation distribution as a means of determining the interconnection between individual bedrock wells and between site monitoring wells and residential wells. An additional round of anion and cation analyses are planned for both new and existing bedrock and overburden wells. The addition of ion data from the overburden will facilitate the evaluation of recharge-discharge relationships as well as provide data concerning the chemical evolution of groundwater. This information can be used to assess the impact that inorganic contaminants are or will be having on the site groundwater. Evaluation of anion and cation distribution data will be the responsibility of EPA, through EPA researchers at the Robert S. Kerr laboratory. Anion/cation analyses of samples from bedrock monitoring wells and any additional residential wells will be used to support this effort.

Geotechnical Analyses, TOC and CEC

Selected soil samples will be collected using thin-walled (Shelby) tubes and sent to an appropriate laboratory for geotechnical analysis. Specific analyses to be conducted include grain size, laboratory permeability, total organic carbon and cation exchange capacity. The results of these tests will be used to define physical soil characteristics needed to evaluate remedial treatment technologies and also in the case of TOC and CEC data, for the calculation of retardation and/or attenuation factors.

ASTM Shake Test

In order to obtain an estimate of inorganic contaminant loading to groundwater (i.e., the concentrations of cyanide and arsenic in leachate generated from soil porewaters percolating through contaminated, unsaturated zone soils), selected subsurface soil samples will be subjected to a modification of the ASTM Shake Test (D3987). Approximately ten soil samples expected to contain relatively high amounts of contamination will be analyzed using this method.

Samples will be selected on the basis of field screening results. The objective of the selection process is to obtain a complete and representative sampling of all contaminated soil at the site. All samples selected for the test will be fully characterized with regard to chemical constituents to assist with interpretation of the test results. The procedure involves the mixing of contaminated soil with clean, upgradient groundwater from the site (which has also been fully characterized). Following a period of agitation (shaking or stirring), the groundwater is separated from the soil and analyzed. Special modifications to the test have been developed to minimize volatile loss and any resulting change in the geochemistry of the soils. These modifications are detailed in the Field Sampling and Analysis Plan.

The results of the ASTM shake tests will provide an indication of the type and magnitude of contaminant leaching from the soil. These data will be used to develop soil cleanup levels or other remedial criteria as needed for the risk assessment and/or feasibility study.

5.4.2 Data Validation

Validation is a systematic process of reviewing a body of data to provide assurance that the data are adequate for their intended use. The process includes the following activities:

- o Auditing measurement system calibration and calibration verification,
- o Auditing quality control activities,
- o Screening data sets,
- o Reviewing data for technical credibility versus the sample site setting,
- o Checking intermediate calculations, and
- o Certifying the previous process.

The review and validation of CLP and REM III laboratory data will be conducted by REM III Team chemists in accordance with EPA Central Regional Laboratory validation requirements.

5.4.3 Sample Tracking

Ebasco's Regional Laboratory Sample Coordinator (RLSC) will track the samples sent to CLP to assure the continuity and consistency of data and analyses throughout the sampling program. Tracking will include tabulating the dates samples are obtained, dates shipped, analyses performed, holding times, dates extracted or analyzed, and dates validated.

5.5 TASK 5 - DATA EVALUATION

There are two elements to this task; the first involves data reduction and tabulation to organize validated data and other information collected during the field investigation into a working format for analysis. The second element involves performing the necessary evaluations to meet the project objectives. A summary of the types of data, evaluation methods, and expected products from the data evaluation activities associated with each operable unit is shown in Table 5-3.

5.5.1 Operable Unit 1

Evaluation of analytical data and other information pertinent to OU1 collected during the field investigation will be a primary activity of the Task 16 FFS. A brief summary of data evaluation activities for OU1 is given in Table 5-3. A more complete discussion of OU1 data evaluation is contained in Section 5.13.

5.5.2 Operable Unit 2

Evaluation methods for the physical and chemical data from monitoring well installation, aquifer testing, geophysical logging and groundwater and surface water sampling activities are summarized in Table 5-3. Data evaluation activities will begin in the field (e.g., selecting completion depths or packer test intervals from rock core/geophysical log data) and continue through development of the Final RI Report.

5.5.3 Operable Unit 3

Evaluation of physical and chemical data from soil sampling and analysis activities will begin during field screening activities that will be used to identify selected samples for laboratory analysis. Detailed evaluation of field data and laboratory tests results will be conducted after the field investigation has been completed. For OU3, data evaluation objectives are to define the nature and extent of soil contamination and the geochemical relationships between contaminants and the soil matrix. A number of evaluation methods will be used as summarized in Table 5-3.

5.5.4 Operable Unit 4

The visual inspection reports and soil sample analytical results (if any) from the test trenches will be assembled, reviewed, and evaluated. Trench (or test pit) logs will be prepared and included in the RI report. A comparison will be made between OU4 data and that collected for the other three operable units to determine if the anomaly locations contribute to site ground water or soil contamination.

5.6 TASK 6: ASSESSMENT OF RISKS

This section describes the tasks involved in evaluating the potential impacts of site contamination on human health and the environment.

TABLE 5-3
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
SUMMARY OF DATA EVALUATION TECHNIQUES

DATA			
SOURCE	TYPE	METHOD OF EVALUATION	PRODUCT
OU 1:			
Container Inventory	Number and Size	Compilation	Scope of Removal Efforts Required, Identification of Possible Hazards, Recommend Disposal and Recycling Methods
	Contents	Comparison w/Hazard or Toxicity Data	
Lagoon 3 (Vault) Sludge/Kiln Dust	Waste Characterization Data	Input into Incineration or Other Treatment Technology Models	Optimum Treatment Methods Incineration Parameters
Soils	Waste Characterization Data	As Above	As Above
	Analytical Data	Reduction, Compilation Comparison w/Background Comparison w/Groundwater	Summary Tables, Concentration Profiles, Identification of "Hot Spots", Estimates of Contaminant Loading and Mobility
OU 2:			
Monitor Wells	Aquifer Test Results	Graphical and Analytical Solutions	Aquifer Parameters (K, T, S) Interconnection of Wells & Aquifers, Estimates of Flow Rate Distribution
	Analytical Results	Reduction, Compilation Statistical Analyses Mapping, Comparison w/Soils Data	Background Concentrations, Plume Dimensions
	Borehole Geophysical Logs	Log Analyses Techniques Correlation	Location of Fractures, Fracture Size, Stratigraphy
	Single Well & Multi-well Tracer Test Results	Reduction, Compilation Plotting Conc vs Time	Groundwater Velocity

TABLE 5-3 (Continued)
GREENWOOD CHEMICAL SITE - RI/FS WORK PLAN
SUMMARY OF DATA EVALUATION TECHNIQUES

DATA			
SOURCE	TYPE	METHOD OF EVALUATION	PRODUCT
OU 3:			
All Borings (Soil Borings, Monitor Well Borings and Auger Borings	Field Screening Results	Comparison w/Reference Standards & Contaminant-Specific Criteria	Identification of Samples for Laboratory Analysis
	Arsenate/Arsenite F&D Cyanide	Reduction, Compilation Geostatistical Analyses	Distribution of Trivalent Arsenic and Free & Dissociable Cyanide in Site Soils
	ASTM Shake Test	Calculation of Contaminant Partition Coefficients	Estimate of Contaminant Mobility
Upgradient Borings and Sediment Samples	Analytical Results	Reduction, Compilation Geostatistical Analyses	Background Concentations for Organic & Inorganic Chemicals
Source-area and Downgradient Borings (Including Former Drum Burial Area) and Sediment Samples	Analytical Results	Reduction, Compilation Mapping, Geostatistical Analyses (where applicable) Comparison w/Groundwater Data, Comparison w/Background Soils Data	Summary Tables, Concentration Profiles, Spacial Patterns of Contamination, Estimates of Mobility, Contaminant Leaching or Loading to Groundwater, Location of Hot Spots
	Geotechnical Test Results Boring Logs	Reduction, Compilation	Summary Tables, Physical Soil Parameters for Use in Remedial Alternatives Evaluation
OU 4:			
Test Pits	Field Observations	Visual Examination	Source of Magnetic Anomaly
	Analytical Results	Reduction, Compilation Comparison w/Background	Summary Tables, Concentration Profiles, Spatial Patterns of Contamination, Source Contribution from Underground Structures

5.6.1 Public Health Evaluation

The objective of the public health evaluation is to assess potential impacts on public health and the environment from actual or potential releases from the Greenwood Chemical Site. Such an assessment evaluates the site and surrounding areas in the absence of remediation, and will be based on the data collected during the two REM III interim field investigations, the EPA removal action, and sampling to be completed during the RI/FS.

The site has been divided into four OU's. Based on the Task 14 document and the interim field investigations, it has been determined by EPA that the no-action alternative is not appropriate for Operable Unit 1; therefore, a Focused Feasibility Study will be performed for this OU. The Task 14 document (Final Remedial Cleanup Criteria for lagoons 1, 2, and 3) will serve as the risk assessment for OU1 (this issue is addressed in greater detail in Section 5.13). It should also be noted, as discussed in Section 3.1.1, insufficient information is available to perform a risk assessment for OU4, the underground structures (magnetic anomalies). It has been assumed (for scoping, budgeting and scheduling purposes) that a separate risk assessment will be performed only for OU2 and OU3. Discussed below are the tasks involved in evaluating potential human health impacts for OU2 and OU3 at the Greenwood Chemical Site.

The baseline public health evaluation will address the potential human health effects associated with exposure to the contaminants present in the media of concern for each OU. Media of concern for OU2 include the overburden and bedrock groundwater, pond surface water, stream sediments and surface water, and Lagoons 4 and 5 sediments and surface water. Contaminated soils in various study areas, apart from those addressed in OU1, are of concern for OU3. For risk assessment purposes, these study areas are defined as the source areas (including drum handling area, backfill areas, and process area) and downgradient areas to the south and southeast.

The results of the sampling and analysis for these media will be reviewed in order to identify medium-specific chemicals of potential concern. Key elements in this process are a comparison of site concentrations of inorganic chemicals to background levels of chemicals in appropriate media. In addition, chemicals present in sample blanks (i.e., laboratory or field contaminants) will be evaluated as to whether they are actual indicators of site related contamination.

The preliminary risk assessment performed as part of Task 14 identified several chemicals of potential concern in the soils, sediments, and groundwater at the Greenwood Chemical Site. The sampling data used to identify these chemicals will be evaluated in conjunction with data generated as part of the remedial investigation in order to determine the need to evaluate fewer or additional chemicals in any one medium. Based on the interim field investigations, several media in both OU2 and OU3 contained naphthalene-based and benzene-based Tentatively Identified Compounds (TICs). Although the qualitative and quantitative analytical information for these chemicals are suspect, their prevalence at the Greenwood Chemical Site indicates that they may comprise a significant portion of the contamination and are therefore included as chemicals of potential concern.

The next step in the risk assessment involves an evaluation of potential exposure pathways specific to the Greenwood Chemical Site. Exposures will be characterized by constructing exposure scenarios that define the source of contamination, route of transport, possible receptors, and the likely routes of exposure (e.g., ingestion, inhalation). For each exposure scenario, concentrations in relevant environmental media at the potential receptor locations will be identified. Where concentrations have been measured at the exposure point, estimates of current or future concentrations may, in certain instances be made using models. Based on Section 3.0 of this Work Plan, the evaluation provided in Section 4 of the Task 14 document, and on the observations during the site visit, the primary exposure pathway of concern for OU2 involves the migration of groundwater contaminants to off-site, downgradient receptors and/or future use of contaminated groundwater in either the overburden or the bedrock aquifers as potable drinking water sources. For Lagoons 4 and 5, included as part of OU2, pathways of potential concern include the exposure of terrestrial life which may use the waters of the lagoons as a drinking water source and direct contact (e.g., dermal absorption of sediment contaminants) by individuals wading or swimming in the lagoons. No chemicals of concern were detected in the west stream, therefore, exposures to the surface water and sediments in this tributary are not expected to be evaluated.

Pathways of potential concern for OU3 are direct contact with contaminated on-site soils (i.e., incidental ingestion and dermal absorption of soil contaminants by trespassers on site, by future workers if the site is re-developed for industrial use, and by hypothetical future residents. The future residential development of the site is considered possible since the area surrounding the site is primarily residential. In addition, the inhalation of contaminated particulate materials (emitted from the site via wind erosion) by on-site and off-site individuals will be evaluated using the results of simple emission rate and dispersion models. Finally, the exposure of on-site individuals to site-related contamination via the leaching of contaminants from the soils to the groundwater with subsequent ingestion of the groundwater by current off-site and future on-site residents will be assessed.

A toxicity assessment, including the identification of critical toxicity criteria, will be performed for each chemical of concern in each medium of concern at the Greenwood Chemical Site. In the quantitative risk characterization section, these toxicity values will be combined with the intake values described in the next step of the risk assessment. For humans, toxicity data for potential carcinogens will be presented in terms of the carcinogenic potency factor (in units of (mg/kg/day)-1). For noncarcinogens, the estimated reference dose (RFD) in the units of mg/kg/day will be presented. In addition, qualitative discussions of the toxicity of each chemical of potential concern will be included in the risk assessment. It should be noted that the qualitative toxicity evaluation of arsenic and cyanide, two inorganic chemicals of potential concern in several media for both OU2 and OU3, will include a discussion of the relative toxicity of different forms (or species) of these two chemicals present.

Concerning the qualitative toxicity assessment of TICs, certain TICs have not been even minimally characterized for acute or chronic human health effects, but where possible, brief summaries of available toxicity data for the TICs will be provided. A toxicity information search will be conducted for the TICs, using sources such as the National Library of Medicine's Hazardous Substance Data Bank (HSDB), which contains data on more than 4,100 chemical substances that are of known or potential toxicity and to which substantial populations may be exposed.

In addition to critical toxicity values, any applicable or relevant and appropriate requirement (ARARs) that have been established for the chemicals of concern will be identified. Currently, EPA considers maximum contaminant levels (MCLs) developed under the Safe Drinking Water Act, federal ambient water quality criteria (AWQC), national ambient air quality standards (NAAQS), and Virginia environmental standards to be some of the standards or criteria that are potential ARARs for use in risk assessment at Superfund sites. Potential ARARs for the Greenwood Chemical Site are shown in Table 3-1.

The ARARs presented in the toxicity assessment will be used to assess the potential adverse effects of chemicals in each OU on human health by comparison with concentrations found at or near the site. For example, OU2 groundwater concentrations found in the overburden and bedrock aquifers under the site as well as off-site groundwater concentrations determined through residential well sampling will be compared with MCLs. However, since ARARs are not expected to be available for all of the chemicals of potential concern in all media of OU2 and OU3, a quantitative risk characterization will be performed for the exposure scenarios of concern.

Part of this quantitative risk characterization will entail the estimation of chemical intakes for each exposure scenario based on frequency and duration of exposure and rate of media intake (e.g., the amount of soil contacted and ingested, the amount of water ingested, the amount of air breathed per day). The assumptions used in these intake estimates (e.g., activity patterns, consumption of groundwater, chemical-specific absorption factors, etc.) will be documented to the extent possible. Based on preliminary information and observations during a recent site visit, it is anticipated that several of the exposure scenarios will be hypothetical; that is, although the potential for the type of exposure exists, there is no evidence that it currently occurs. The exposure assumptions will be selected to represent an "average" case and a "plausible maximum" case and will be used in conjunction with average and maximum media concentrations in order to calculate average and plausible maximum chemical intake estimates.

Evaluation of the noncarcinogenic health risks associated with contaminants of concern considered in this risk assessment will be based primarily on a comparison of the estimated daily intake of the indicator chemicals with appropriate critical toxicity values for the protection of human health described in the toxicity assessment. For potential carcinogens, the estimated cancer risks associated with exposure are calculated by multiplying the cancer potency factor presented in the toxicity assessment by the daily intake of the chemical of concern. As suggested in EPA guidance for evaluating mixtures, for a specific exposure scenario, the chemical-specific upperbound excess lifetime cancer risks will be summed. In addition, hazard indices for noncarcinogenic chemical mixtures will be determined by summing the ratios of the daily intake to RFD for each chemical of concern.

Quantitative risk characterization results will be presented separately for the "average case" and for the "plausible maximum case". The risk characterization for each exposure pathway will include a discussion of the uncertainties in the estimates.

5.6.2 Environmental Assessment

As part of the risk assessment, the potential for the site to adversely impact non-human populations will be evaluated. This evaluation will address endangered species, critical habitats, and valued natural resources. As noted in Section 3.0, based on the limited contamination detected and the use of ponds, lagoons, and creeks, toxicity to aquatic life from site-related chemicals is not expected. The environmental assessment will consist primarily of a qualitative assessment of the toxicity of exposure to chemicals by plants, wildlife, and aquatic life. This will be followed by a risk characterization if necessary (i.e., a quantitative assessment based on critical ecological toxicity criteria).

5.7 TASK 7 - TREATABILITY STUDIES

Treatability studies are not planned under the present scope of work. However, soil/sludge characterization tests will be conducted for OU1 and some OU3 samples to determine if these materials are suitable for thermal treatment of organic-contaminated soils. If it becomes apparent that treatability studies are warranted for the other operable units they may be performed during the remedial design phase.

5.8 TASK 8 - REMEDIAL INVESTIGATION REPORT

A remedial investigation report for operable Units 2, 3 and 4 will be prepared at the conclusion of the RI. This report will summarize the data collected, procedures used, and the conclusions drawn from each of the operable units. The RI report will be prepared according to the format provided in the USEPA draft RI guidance (OSWER Directive 9355.3-01, Page 3-55). Modifications to the format will be made as necessary to meet site-specific project conditions. The report will be submitted as a draft for EPA (and other agencies, if required) review with revisions completed in a timely manner.

5.9 TASK 9 - REMEDIAL ALTERNATIVES SCREENING FOR OPERABLE_UNITS 2, 3, AND 4

The existing chemical characterization and preliminary risk data for the Greenwood Chemical Site indicates that it is likely that an evaluation of containment and treatment alternatives will be necessary for Operable Units 2 and 3. This assumption is based on the following observations:

- o Groundwater contamination at the site exceeds potential ARAR concentrations (i.e., Virginia State Groundwater Standards);
- o Soil contamination in excess of preliminary action levels was detected at several locations in areas not addressed by the OU1 FFS (e.g., former buried drum area).

Therefore, screening of alternatives (including the No Action alternative) is necessary and will be conducted under this task. There is insufficient data to determine whether the No Action alternative is clearly appropriate for Operable Unit 4. Because it is not possible to define the scope of screening, resources have not been allocated at this time for potential OU4 activities under Task 9.

Based on the results of the risk assessment and remedial response objectives developed for Operable Units 2 and 3, an initial screening of remedial alternatives will be performed as recommended in the EPA's "Guidance on Feasibility Studies under CERCLA", and Porter's "Interim Guidance on Superfund Selection of Remedy" (December 1986) and (July 1987).

The list of potential remedial technologies/alternatives for OU's 2 and 3 will be screened according to the guidance cited above and in Section 300 of the National Contingency Plan (NCP). The principal objective of this effort is to eliminate alternatives on the basis of effectiveness and implementability. Cost plays little or no role in the initial screening process unless the fourth criterion presented below clearly applies. The screening process involves the elimination of alternatives that:

- May have a significant adverse impact during implementation.
- Do not adequately protect the environment and public health.
- Have technical feasibility which is either difficult to implement or not proven.
- Have costs an order of magnitude greater than other alternative(s) but do not provide greater environmental or public health benefits or greater reliability.

The Superfund Amendments and Reauthorization Act (SARA) addresses the cleanup standards for Superfund remedial actions and requires that the selected remedy should utilize permanent solutions and alternative treatment technologies, or resource recovery technologies to the maximum extent practicable. In addition, SARA requires that volume reduction of waste and contaminated soil should be considered in addition to the reduction of toxicity and/or mobility. These applicable provisions of SARA will be applied during the screening of remedial technologies and alternatives.

5.10 TASK 10 - DETAILED EVALUATION OF REMEDIAL ALTERNATIVES FOR OPERABLE UNITS 2, 3, & 4

The remedial alternatives that pass the initial screening will be evaluated in further detail. This evaluation will conform to the requirements of the NCP, in particular, Section 300.68 (h), Subpart F, and will consist of a technical, environmental and cost evaluation as well as an analysis of other factors, as appropriate. As specified in the EPA Guidance on Feasibility Studies under CERCLA, and updated in Porter's December 1986 and July 1987 Memorandum on "Interim Guidance on Superfund Selection of Remedy", the criteria for the detailed evaluation include:

- Compliance with ARARs;
- Reduction of toxicity, mobility or volume;
- Short-term effectiveness;
- Long-term effectiveness/permanence;
- Implementability;
- Cost;
- Community acceptance;
- State acceptance; and
- Overall protection of human health and the environment.

Factors which might be considered when applying each of the above criteria will be those delineated in OSWER Directive 9355.0-21.

Public Health Evaluation data will be used in identifying appropriate cleanup standards or criteria for those chemicals and pathways which present a significant risk for each OU. In addition, the impact of selected remedial alternatives on the baseline estimated risks will be qualitatively assessed. It should be noted that the effect of these remedial actions may not necessarily be a reduction in risk, particularly during the remedial action period. For example, removal and off-site disposal of contaminated soils may create an additional exposure pathway and resultant risk. Hence, short-term risks resulting from application of the remedial action itself will also be considered.

5.11 TASK 11 - FEASIBILITY STUDY REPORT

A Feasibility Study report for Operable Units 2, 3 and 4 will be prepared to summarize the FS activities performed and to present the results of the alternative evaluation for each unit. The FS report will be prepared according to the format provided in the EPA FS guidance (OSWER Directive 9355.3-01, Page 7-88). Modifications to the format will be made as necessary to meet site-specific project conditions. The report will be submitted as a draft to EPA for review. Revisions will be completed in a timely manner. The final FS report results will be presented at a public meeting held at a date selected by the EPA.

5.12 TASK 12 - POST RI/FS SUPPORT

It is estimated that minimal post-RI/FS technical support will be required by the REM III team. Support will be provided for one public meeting/hearing. This may include preparation of graphics, assistance in planning and logistics of the public meeting, and preparation of a responsiveness summary. Additional support will be provided at the direction and authorization of EPA.

The responsiveness summary will record public comments submitted during or prior to the comment period and document how EPA or the State of Virginia responded to the issues raised by the public. This summary is prepared after the close of the public comment period on the Feasibility Study Report. It is expected that EPA or the state will assist in the preparation of the necessary responses to comments received.

Support may also be provided for the preparation of the Record of Decision (ROD). This will be provided at the request and authorization of EPA.

5.13 TASK 16-FOCUSED FEASIBILITY STUDY FOR OPERABLE UNIT 1

Results of sampling during removal and interim RI/FS actions at the Greenwood Chemical Site and the preliminary risk assessment (Section 3.1) indicate that the "No Action" alternative is unlikely for lagoon soils, stabilized sludge, and for the remaining on-site drums/containers for which Greenwood Chemical Company has not defined an intended use or interest in retaining. In order to facilitate remedial action alternative selection for these materials, they have been included in a separate Operable Unit (OU1) and have been targeted for a Focused Feasibility Study (FFS).

5.13.1 FFS Objectives

The overall objective of the FFS is to collect and analyze data and provide the engineering evaluations necessary to support a Record of Decision (ROD) for the unit of concern. Specific objectives include:

1. To document the rationale for remedial action for OU1 (i.e., why the "no action alternative" is inappropriate),

2. To develop soil clean-up levels for organic-contaminated soils,

3. To refine estimates concerning the volume of material requiring remediation,

4. To determine the appropriate remedial alternatives that address sludge, organic-contaminated lagoon soils and other components of OU1 that present an unacceptable risk to either human health or the environment.

5.13.2 FFS Activities

In order to accomplish these objectives, a number of FFS activities will be conducted. Each will be examined below.

Site Characterization

A limited amount of additional site characterization data is needed to assess the suitability of certain remedial technologies for treating OU1 components. These data will also be used to assess the probable impact that these contaminant sources are having on the major exposure pathway of concern (i.e., groundwater). Field investigation activities for the OU1 FFS entail the collection of two samples from each of the following:

- Lagoon 1 and 2 (natural soils)
- Lagoon 3/vault (stabilized waste)
- Backfill North (sludge/soil)

Samples will be collected using a hand auger or stainless steel scoop/trowel where possible. Access to deeper samples (e.g., in Lagoon where an estimated four feet of backfill material overlies natural soils) will be obtained with a backhoe.

The eight samples collected for OU1 will be analyzed for the incineration suitability parameters discussed in Section 5.4. The resulting data will be used during the detailed evaluation of remedial alternatives to assess the feasibility of selecting a thermal treatment system for remediation of OU1.

The results of additional extent-of-contamination sampling of soils underlying Lagoons 1 and 2 will be utilized to develop more detailed volume estimates. This additional data may not be available until after the Draft FFS is submitted to EPA; if so, it will be incorporated into the Final FFS report.

Risk Assessment

A separate risk assessment for the OU1 FFS will not be completed. Rather, the relevant portions of the document "Final Remedial Cleanup Criteria for lagoons 1, 2 and 3 (Task 14)" will serve as the risk assessment for OU1. In finalizing the Task 14 document, Ebasco will verify the tentative soil cleanup levels developed for the February 1988 draft document. The cleanup levels will be for both VOCs and semivolatiles and reflect the 10^{-4} to 10^{-7} carcinogenic risk for the pathways of concern (groundwater consumption and direct contact).

Remedial Alternatives Evaluation

A number of potential remedial alternatives will be screened to identify a limited number for detailed evaluation. Preliminary screening analyses conducted during the planning process for this FFS have identified several alternatives likely to be retained for detailed evaluation. These detailed evaluations will be the primary focus of the FFS report.

In addition to the no action alternative, it is expected that five alternatives will be evaluated: three of these involve treatment, the other two containment. Based on the results of a thermal treatability study completed by Ebasco (7/13/88; part of the interim remedial activities at Greenwood), the three treatment alternatives expected to be evaluated in detail are:

- Low-temperature volatilization
- On-site incineration
- Off-site incineration

The cost portions of these evaluations will show the significance of the volume estimates developed during the FFS and RI/FS for these lagoon soils. Development of volume estimates of materials requiring remediation will be based on the results of the Task 14 Risk Assessment (i.e., acceptable soil concentrations) as well as data from Lagoon 1 and 2 and Backfill North soil borings for the OU3 investigation. Cost will be a particularly critical factor in the evaluation of on- versus off-site treatment. The alternatives evaluation will document the point where on-site treatment is more cost-effective.

6.0 PROJECT MANAGEMENT APPROACH

6.1 ORGANIZATION AND APPROACH

The proposed project organization for the Greenwood Chemical Site FFS and RI/FS is shown in Figure 6-1. The Regional Manager (RM), Mr. Richard C. Evans, P.E., and John Gorgol, Deputy Regional Manager will provide the overall direction for this project. Mr. Evans implements the program standard of quality in the region and makes sure that the project Site Manager (SM) maintains that standard. The RM's review concentrates on the technical quality, schedule, and cost for all work assignments. Dennis Beissel will serve as the project Site Manager (SM). The SM has the primary responsibility for implementing and executing the RI/FS and FFS. Supporting the SM are the Field Operations Leader (FOL), the RI leader, the FS leader, and other technical support staff. The FOL is responsible for the onsite management of activities for the duration of the site investigation. The RI leader is responsible for the implementation of the RI and preparation of the RI report. The FS leader is responsible for the implementation and preparation of the FS report.

The RI/FS and FFS tasks included in this Work Plan, in addition to the Schedule and budget, comprise the baseline plans against which work assignment progress can be measured. The baseline plans are a description of how the work assignment will be executed in terms of scope, schedule, and budget. The project schedule and detailed cost estimate are presented in Sections 6.3 and 6.4 respectively.

6.2 QUALITY ASSURANCE AND DATA MANAGEMENT

The site-specific quality assurance requirements will be in accordance with the Quality Assurance Program Plan (QAPP) for the REM III program, as approved by EPA. The REM III QAPP provides general guidance on the following subjects:

- Project organization and responsibility, and

- QA objectives for measurement of data in terms of precision, accuracy, representativeness, completeness, and comparability.

Data management aspects of the program pertain to controlling and filing documents. Ebasco has developed a program filing system (Administrative Guideline Number PA-5) that conforms to the requirements of EPA in the REM III Program to ensure that the integrity of the document is safeguarded. This guideline will be implemented to control and file all documents associated with the Greenwood Chemical Site RI/FS and FFS. The system includes documents receipt control procedures, a file review and inspection system, and security measures to be followed.

6.3 PROJECT SCHEDULE

Figure 6-2 (in the back pocket) provides a detailed illustration of each of the work task activities and their schedule. The schedule for the field investigation assumes that no site restrictions will be encountered and is dependent upon EPA approval of this Work Plan and the FOP by the specified dates.

6.4 COST ESTIMATES

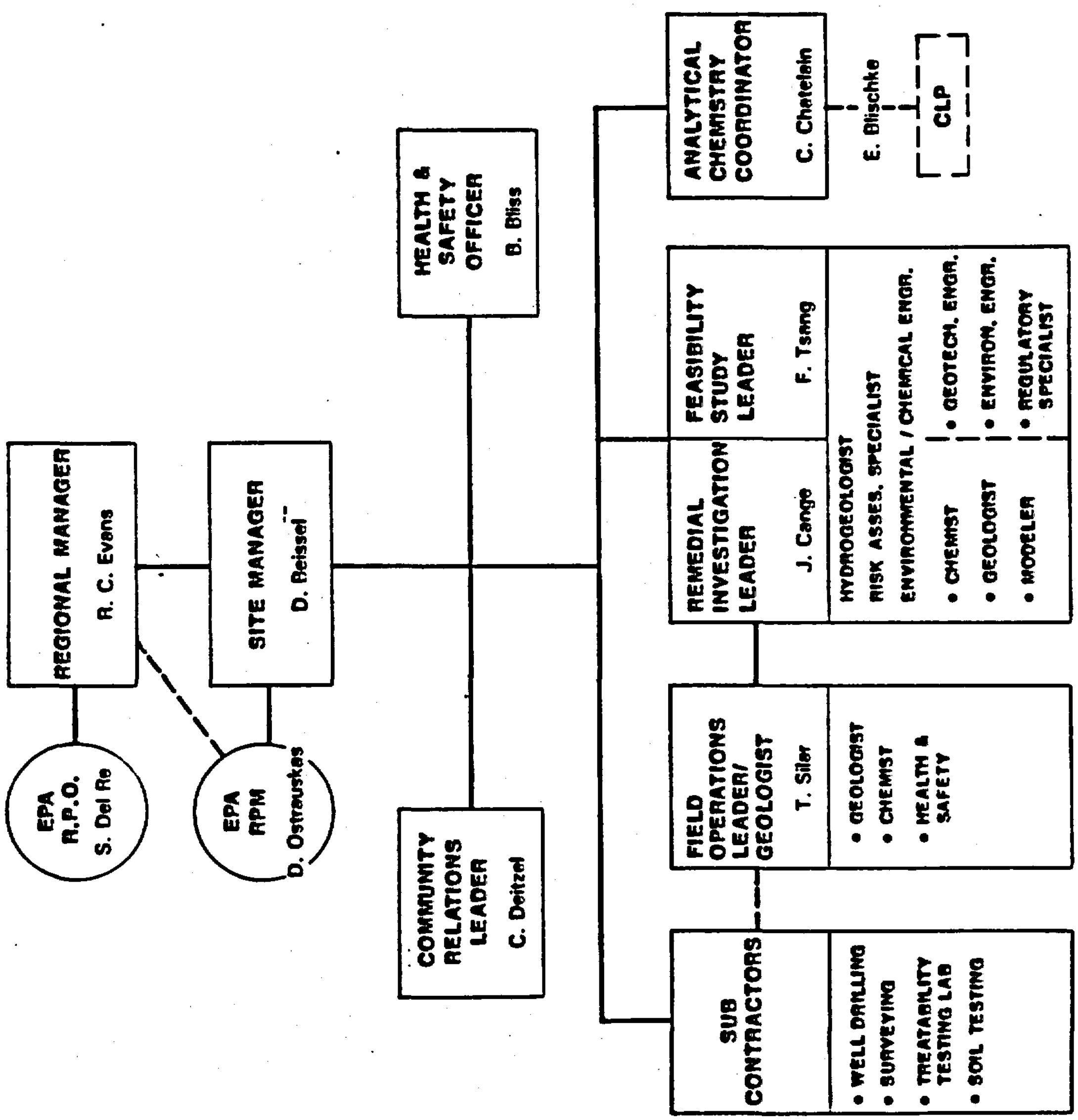
The detailed cost estimate for the Greenwood Chemical Site RI/FS and FFS presented under separate cover in the Optional Form 60 (OF-60).

These costs only include activities described in this Work Plan, and costs for laboratory analyses are not included. The cost estimate is based on performing the field investigation under Level "D" personal protection (and minimal activities at Level "C"). Should it be determined that Level "B" of "A" personal protection is required, the cost estimate will be revised.

To the maximum extent practicable, all costs for performance of the FFS for OU1 have been separated and reported under Task 16. It has been assumed that Task 16 will be performed in parallel with the RI/FS Tasks as shown in the project schedule (Figure 6-2). Certain costs reported for the Task 16 field investigation have been reduced because of assumed synergistic effects resulting from the RI/FS field investigation (e.g., mobilization costs).

FIGURE 6-1

GREENWOOD CHEMICAL SITE — RI/FS WORK PLAN
PROJECT ORGANIZATION



APPENDIX A

RESIDENTIAL AND MONITORING WELL
GROUNDWATER SAMPLING ANALYSES RESULTS
INTERIM FIELD INVESTIGATION MAY 1988

GREENWOOD CHEMICAL SITE RI/FS
RESIDENTIAL WELL GROUNDWATER ANALYSES
VOLATILE ORGANIC ANALYSES
(UG/L)

DATE: 08/19/88
PAGE 1

SAMPLE ID	RW-01		RW-02		RW-03		RW-04		RW-05		RW-07		RW-08	
VINYL CHLORIDE	10.000	U	10.000	U	10.000	U	10.000	U	10.000	U	10.000	U	10.000	U
METHYL CHLORIDE	4.000	BJ	4.000	BJ	26.000	B	5.000	B	6.000	B	7.000	B	32.000	B
ACETONE	2.000	BJ	1.000	BJ	2.000	BJ	2.000	BJ	2.000	BJ	4.000	BJ	3.000	BJ
CHLOROFORM	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
1,2-DICHLOROETHANE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
1,1,1-TRICHLOROETHANE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
CARBON TETRACHLORIDE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
TRICHLOROETHENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
BENZENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
TETRACHLOROETHENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
TOLUENE	1.000	U	1.000	U	1.000	U	1.000	U	1.000	U	1.000	U	1.000	U
CHLOROBENZENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
ETHYLBENZENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
TOTAL TICS	0.000		0.000		0.000		0.000		0.000		0.000		0.000	
TIC CONCENTRATION	0.000	A	0.000	A	0.000	A	0.000	A	0.000	A	0.000	A	0.000	A

EXPLANATION OF CODES:

J - ESTIMATED VALUE
B - COMPOUND FOUND IN BLANK
  - DETECTED AT CONCENTRATION SHOWN
U - UNDETECTED AT GIVEN INSTRUMENT DETECTION LIMIT
R - NOT REQUIRED FOR ANALYSIS
X - REJECTED VALUE
A - TICS ANALYZED FOR BUT NOT FOUND
  (TICS = TENTATIVELY IDENTIFIED COMPOUNDS)

GREENWOOD CHEMICAL SITE RI/FS
RESIDENTIAL WELL GROUNDWATER ANALYSES
VOLATILE ORGANIC ANALYSES
(UG/L)

SAMPLE ID	RW-09		RW-10		RW-11-01		RW-11-02		RW-12	
VINYL CHLORIDE	10.000	U	10.000	U	10.000	U	10.000	U	10.000	U
METHYL CHLORIDE	3.000	BJ	4.000	BJ	12.000	B	5.000	B	18.000	B
ACETONE	4.000	BJ	4.000	BJ	10.000	B	9.000	BJ	4.000	BJ
CHLOROFORM	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
1,2-DICHLOROETHANE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
1,1,1-TRICHLOROETHANE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
CARBON TETRACHLORIDE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
TRICHLOROETHENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
BENZENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
TETRACHLOROETHENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
TOLUENE	1.000	U	1.000	U	3.000	BJ	3.000	BJ	1.000	U
CHLOROBENZENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
ETHYLBENZENE	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
TOTAL TICS	0.000		0.000		0.000		0.000		0.000	
TIC CONCENTRATION	0.000	A	0.000	A	0.000	A	0.000	A	0.000	A

EXPLANATION OF CODES:

J - ESTIMATED VALUE
B - COMPOUND FOUND IN BLANK
  - DETECTED AT CONCENTRATION SHOWN
U - UNDETECTED AT GIVEN INSTRUMENT DETECTION LIMIT
R - NOT REQUIRED FOR ANALYSIS
X - REJECTED VALUE
A - TICS ANALYZED FOR BUT NOT FOUND
    (TICS = TENTATIVELY IDENTIFIED COMPOUNDS)

GREENWOOD CHEMICAL SITE RI/FS
RESIDENTIAL WELL GROUNDWATER SAMPLES
BNA ANALYSES
(UG/L)

SAMPLE ID	RW-01	RW-02	RW-03	RW-04	RW-05	RW-07	RW-08
1,2-DICHLOROBENZENE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
2-METHYLPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
4-METHYLPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
2-NITROPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
BENZOIC ACID	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U
NAPHTHALENE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
BIS(2-ETHYLHEXYL)PHTHALATE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	9.000 J	10.000 U
TOTAL TICS							
TIC CONCENTRATION	20.000 BJ	0.000 A	80.000 BJ	40.000 BJ	40.000 BJ	36.000 BJ	48.000 BJ

EXPLANATION OF CODES:

J - ESTIMATED VALUE
B - COMPOUND FOUND IN BLANK
  - DETECTED AT CONCENTRATION SHOWN
U - UNDETECTED AT GIVEN INSTRUMENT DETECTION LIMIT
R - NOT REQUIRED FOR ANALYSIS
X - REJECTED VALUE
A - TICS ANALYZED FOR BUT NOT FOUND
    (TICS = TENTATIVELY IDENTIFIED COMPOUNDS)

GREENWOOD CHEMICAL SITE RI/FS
RESIDENTIAL WELL GROUNDWATER SAMPLES
BNA ANALYSES
(UG/L)

SAMPLE ID	RW-09	RW-10	RW-11-01	RW-11-02	RW-12
1,2-DICHLOROBENZENE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
2-METHYLPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
4-METHYLPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
2-NITROPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
BENZOIC ACID	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U
NAPHTHALENE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
BIS(2-ETHYLHEXYL)PHTHALATE	10.000 U	10.000 U	5.000 BJ	10.000 U	10.000 U
TOTAL TICS					
TIC CONCENTRATION	20.000 BJ	0.000 BJ	68.000 J	146.000 BJ	18.000 BJ

EXPLANATION OF CODES:

J - ESTIMATED VALUE
B - COMPOUND FOUND IN BLANK
- DETECTED AT CONCENTRATION SHOWN
U - UNDETECTED AT GIVEN INSTRUMENT DETECTION LIMIT
R - NOT REQUIRED FOR ANALYSIS
X - REJECTED VALUE
A - TICS ANALYZED FOR BUT NOT FOUND
(TICS = TENTATIVELY IDENTIFIED COMPOUNDS)

GREENWOOD CHEMICAL SITE RI/FS
RESIDENTIAL WELL GROUNDWATER SAMPLES
INORGANIC ANALYSES
(UG/L)

SAMPLE ID	RW-01	RW-02	RW-03	RW-04	RW-05	RW-06	RW-07
ALUMINUM	100.000 U	100.000 U	100.000 U	100.000 U	100.000 U	100.000 U	100.000 U
ANTIMONY	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U
ARSENIC	3.000 U	3.000 U	3.000 U	3.000 U	3.000 U	3.000	3.000 U
BARIUM	149.000	182.000	5.000 U	50.000	5.000 U	5.000 U	29.000
BERYLLIUM	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U
CADMIUM	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
CALCIUM	6610.000	2700.000	27100.000	55300.000	11700.000	36400.000	4120.000
CHROMIUM	4.000 U	4.000 U	4.000 U	4.000 U	4.000 U	4.000 U	4.000 U
COBALT	6.000 U	6.000 U	6.000 U	6.000 U	6.000 U	6.000 U	6.000 U
COPPER	68.000	68.000	20.000	128.000	21.000	118.000	73.000
IRON	137.000	267.000	118.000	100.000	100.000 U	144.000	290.000
LEAD	6.500	2.300	2.200	2.400	2.000	2.300	7.000
CYANIDE	10.000 U	10.000 U	10.000 R	10.000 R	10.000 R	10.000 U	10.000 U
MAGNESIUM	1050.000	1130.000	3550.000	24600.000	4860.000	9530.000	1650.000
MANGANESE	7.000 U	7.000 U	29.000	7.000 U	7.000 U	10.000	7.000 U
MERCURY	0.200	0.200 U	0.200 U	0.400	0.500	0.200 R	0.200 U
NICKEL	11.000 U	11.000 U	11.000 U	11.000 U	11.000 U	11.000 U	11.000 U
POTASSIUM	1000.000	700.000	500.000 U	900.000	500.000 U	500.000 U	800.000
SELENIUM	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U
SILVER	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
SODIUM	5090.000	4100.000	8720.000	16700.000	6090.000	11200.000	2530.000
THALLIUM	2.000 U	2.000 U	7.000 U	7.000 U	7.000 U	7.000 U	2.000 U
VANADIUM	4.000 U	4.000 U	4.000 U	4.000 U	4.000 U	4.000 U	4.000 U
ZINC	24.000	929.000	37.000	282.000	639.000	92.000	26.000

EXPLANATION OF CODES:

J - ESTIMATED VALUE
B - COMPOUND FOUND IN BLANK
D - DETECTED AT CONCENTRATION SHOWN
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R - NOT REQUIRED FOR ANALYSIS
X - REJECTED VALUE
A - TICS ANALYZED FOR BUT NOT FOUND
(TICS = TENTATIVELY IDENTIFIED COMPOUNDS)

GREENWOOD CHEMICAL SITE RI/FS
RESIDENTIAL WELL GROUNDWATER SAMPLES
INORGANIC ANALYSES
(UG/L)

SAMPLE ID	RW-08		RW-09		RW-10		RW-11		RW-11-02		RW-12	
ALUMINUM	100.000	U	100.000	U	100.000	U	210.000		157.000		100.000	U
ANTIMONY	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U
ARSENIC	3.000	U	3.000	U	3.000	U	3.000	U	3.000	U	3.000	U
BARIUM	5.200		1110.000		5.000	U	27.000		6.500		5.000	U
BERYLLIUM	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U
CADMIUM	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
CALCIUM	11600.000		8380.000		20600.000		23700.000		22800.000		30400.000	
CHROMIUM	4.000	U	4.000	U	4.000	U	4.600		4.000	U	4.000	U
COBALT	6.000	U	6.000	U	6.000	U	6.000	U	6.000	U	6.000	U
COPPER	163.000		45.000		25.000		27.000		19.000		15.000	
IRON	244.000		614.000		126.000		1530.000		1010.000		2340.000	
LEAD	7.900		7.700		4.700		21.000		20.000		7.300	
CYANIDE	10.000	R	14.000		10.000	U	10.000	U	10.000	U	10.000	U
MAGNESIUM	5080.000		1400.000		9250.000		3980.000		3840.000		9020.000	
MANGANESE	7.000	U	16.000		12.000		42.000		35.000		118.000	
MERCURY	0.200	U	0.200	U	0.200	U	0.200	U	0.200	U	0.200	U
NICKEL	11.000	U	11.000	U	11.000	U	11.000	U	11.000	U	11.000	U
POTASSIUM	500.000		1000.000		500.000		900.000		1000.000		700.000	
SELENIUM	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U
SILVER	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
SODIUM	5960.000		5520.000		7340.000		9740.000		9280.000		10600.000	
THALLIUM	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U
VANADIUM	4.000	U	4.000	U	4.000	U	4.000	U	4.000	U	4.000	U
ZINC	23.000		70.000		128.000		2180.000		1120.000		41.000	

EXPLANATION OF CODES:

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DATE: 08/19/88
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GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
VOLATILE ORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-01		MW-02D		MW-02S		MW-03		MW-04		MW-05		MW-06	
VINYL CHLORIDE	420.000	U	10.000	U	10.000	U	10.000	U	50.000	U	10.000	U	10.000	U
METHYL CHLORIDE	1000.000	B	8.000	B	8.000	B	9.000	B	47.000	B	7.000	B	4.000	BJ
ACETONE	1500.000	B	4.000	BJ	3.000	BJ	3.000	BJ	27.000	BJ	2.000	BJ	2.000	BJ
CHLOROFORM	220.000		5.000	U	5.000	U	5.000	U	93.000		5.000	U	140.000	
1,2-DICHLOROETHANE	420.000	U	5.000	U	5.000	U	5.000	U	25.000	U	5.000	U	5.000	U
1,1,1-TRICHLOROETHANE	210.000	U	5.000	U	5.000	U	5.000	U	25.000	U	5.000	U	5.000	U
CARBON TETRACHLORIDE	210.000	U	81.000		5.000	U	5.000	U	25.000	U	5.000	U	5.000	U
TRICHLOROETHENE	98.000	J	2.000	J	5.000	U	5.000	U	24.000	J	5.000	U	7.000	
BENZENE	200.000	J	5.000	U	5.000	U	5.000	U	18.000	J	5.000	U	5.000	U
TETRACHLOROETHENE	210.000	U	5.000	U	1.000	J	5.000	U	25.000	U	5.000	U	12.000	
TOLUENE	5100.000	B	1.000	U	1.000	U	6.000		640.000	B	1.000	U	1.000	BJ
CHLOROBENZENE	210.000	U	5.000	U	5.000	U	5.000	U	27.000		5.000	U	5.000	U
ETHYLBENZENE	210.000	U	5.000	U	5.000	U	5.000	U	25.000	U	5.000	U	5.000	U
TOTAL TICS	2.000		0.000		0.000		1.000		1.000		0.000		0.000	
TIC CONCENTRATION	1250.000	J	0.000	A	0.000	A	300.000	J	350.000	J	0.000	A	0.000	A

EXPLANATION OF CODES:

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R - NOT REQUIRED FOR ANALYSIS
X - REJECTED VALUE
A - TICS ANALYZED FOR BUT NOT FOUND
    (TICS = TENTATIVELY IDENTIFIED COMPOUNDS)

GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
VOLATILE ORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-07D	MW-07S	MW-09	MW-10-01	MW-10-02	MW-11	MW-12D
VINYL CHLORIDE	4.000 J	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
METHYL CHLORIDE	7.000 B	6.000 B	8.000 B	69.000 B	66.000 B	5.000 B	5.000 B
ACETONE	4.000 BJ	3.000 BJ	3.000 BJ	34.000 B	35.000 B	3.000 BJ	2.000 BJ
CHLOROFORM	7.000	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
1,2-DICHLOROETHANE	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
1,1,1-TRICHLOROETHANE	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
CARBON TETRACHLORIDE	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
TRICHLOROETHENE	6.000	5.000 U	5.000 U	17.000	16.000	5.000 U	5.000 U
BENZENE	11.000	5.000 U	5.000 U	6.000	5.000	5.000 U	5.000 U
TETRACHLOROETHENE	5.000 U	5.000 U	5.000 U	18.000	17.000	5.000 U	5.000 U
TOLUENE	1.000 U	1.000 U	1.000 U	1.000 BJ	1.000 BJ	1.000 U	1.000 BJ
CHLOROBENZENE	16.000	5.000 U	5.000 U	130.000	130.000	5.000 U	5.000 U
ETHYLBENZENE	5.000 U	5.000 U	5.000 U	8.000	8.000	5.000 U	5.000 U
TOTAL TICS	0.000	0.000	0.000	3.000	3.000	0.000	0.000
TIC CONCENTRATION	0.000 X	0.000 A	0.000 A	660.000 J	650.000 J	0.000 A	0.000 A

EXPLANATION OF CODES:

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  (TICS = TENTATIVELY IDENTIFIED COMPOUNDS)

GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
VOLATILE ORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-12S	MW-13-01	MW-13-02	MW-14D	MW-14S	MW-16D	MW-16S
VINYL CHLORIDE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
METHYL CHLORIDE	7.000 B	13.000 B	8.000 B	7.000 B	4.000 BJ	5.000 B	5.000 B
ACETONE	2.000 BJ	2.000 BJ	2.000 BJ	12.000 B	67.000 B	5.000 BJ	3.000 BJ
CHLOROFORM	21.000	5.000 U	5.000 U	12.000	9.000	2.000 J	1.000 J
1,2-DICHLOROETHANE	5.000 U	5.000 U	5.000 U	80.000	55.000	5.000 U	5.000 U
1,1,1-TRICHLOROETHANE	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
CARBON TETRACHLORIDE	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
TRICHLOROETHENE	5.000 U	2.000 J	2.000 J	36.000	11.000	12.000	4.000 J
BENZENE	5.000 U	1.000 J	1.000 J	10.000	5.000	5.000 U	5.000 U
TETRACHLOROETHENE	5.000 U	5.000 U	5.000 U	1.000 J	1.000 J	5.000 U	5.000 U
TOLUENE	1.000 U	1.000 U	1.000 U	1.000 U	1.000 U	1.000 U	1.000 U
CHLOROBENZENE	5.000 U	5.000 U	5.000 U	50.000	38.000	5.000 U	5.000 U
ETHYLBENZENE	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
TOTAL TICS	0.000	0.000	0.000	3.000	2.000	0.000	0.000
TIC CONCENTRATION	0.000 A	0.000 A	0.000 A	220.000 J	208.000 J	0.000 A	0.000 A

EXPLANATION OF CODES:

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GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
BNA ANALYSES
(UG/L)

SAMPLE ID	MW-01	MW-02D	MW-02S	MW-03	MW-04	MW-05	MW-06
1,2-DICHLOROBENZENE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
2-METHYLPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	4.000 J	10.000 U	10.000 U
4-METHYLPHENOL	10.000 U	10.000 U	10.000 U	12.000	10.000 U	10.000 U	10.000 U
2-NITROPHENOL	6.000 J	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
BENZOIC ACID	160.000	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U
NAPHTHALENE	35.000	10.000 U	10.000 U	150.000	19.000	10.000 U	10.000 U
BIS(2-ETHYLHEXYL)PHTHALATE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
TOTAL TICS							
TIC CONCENTRATION	2992.000 J	122.000 BJ	52.000 BJ	422.000 BJ	476.000 BJ	80.000 BJ	44.000 BJ

EXPLANATION OF CODES:

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A - TICS ANALYZED FOR BUT NOT FOUND
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GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
BNA ANALYSES
(UG/L)

SAMPLE ID	MW-07D	MW-07S	MW-09	MW-10-01	MW-10-02	MW-11	MW-12D
1,2-DICHLOROBENZENE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
2-METHYLPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
4-METHYLPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
2-NITROPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
BENZOIC ACID	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U
NAPHTHALENE	17.000	10.000 U	10.000 U	10.000 U	110.000	10.000 U	10.000 U
BIS(2-ETHYLHEXYL)PHTHALATE	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	24.000
TOTAL TICS							
TIC CONCENTRATION	788.000 BJ	100.000 BJ	26.000 BJ	16810.000 J	17390.000 J	20.000 J	0.000 A

EXPLANATION OF CODES:

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GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
BNA ANALYSES
(UG/L)

SAMPLE ID	MW-12S	MW-13-01	MW-13-02	MW-14D	MW-14S	MW-16D	MW-16S
1,2-DICHLOROBENZENE	10.000 U	10.000 U	10.000 U	12.000	13.000	10.000 U	10.000 U
2-METHYLPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
4-METHYLPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
2-NITROPHENOL	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U	10.000 U
BENZOIC ACID	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U	50.000 U
NAPHTHALENE	10.000 U	10.000 U	10.000 U	13.000	19.000	10.000 U	10.000 U
BIS[2-ETHYLHEXYL]PHTHALATE	10.000 U	24.000	10.000 U	26.000	13.000	10.000 U	5.000 J
TOTAL TICS							
TIC CONCENTRATION	40.000 BJ	40.000 J	56.000 BJ	860.000 J	1024.000 J	10.000 BJ	216.000 J

EXPLANATION OF CODES:

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X - REJECTED VALUE
A - TICS ANALYZED FOR BUT NOT FOUND
  (TICS = TENTATIVELY IDENTIFIED COMPOUNDS)

GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
INORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-01 TOTAL		MW-01 TOTAL		MW-02D TOTAL		MW-02D DISSOLVED		MW-02S TOTAL		MW-02S DISSOLVED		MW-03 TOTAL	
ALUMINUM	23500.000		23500.000		24100.000		100.000	U	27800.000		100.000	U	14000.000	
ANTIMONY	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U
ARSENIC	3.000	U	3.000	U	3.000	U	3.000	U	5.000		3.000	U	3.000	U
BARIUM	973.000		973.000		396.000		62.000		2350.000		35.000		448.000	
BERYLLIUM	6.500		6.500		3.400		2.000	U	5.800		2.000	U	2.900	
CADMIUM	14.000		14.000		9.600		5.000	U	11.000		5.000	U	6.000	
CALCIUM	16200.000		16200.000		22600.000		5580.000		48600.000		10200.000		8200.000	
CHROMIUM	15.000		15.000		22.000		4.000	U	16.000		4.000		11.000	
COBALT	73.000		73.000		9.600		6.000	U	29.000		6.000	U	6.200	
COPPER	51.000		51.000		82.000		9.000	U	52.000		9.000	U	46.000	
IRON	49800.000		49800.000		40900.000		100.000	U	35900.000		100.000	U	28300.000	
LEAD	16.000		16.000		21.000		1.000	U	44.000		1.000	U	11.000	
CYANIDE	12.000		12.000		10.000	U	10.000	R	10.000	U	10.000	R	10.000	U
MAGNESIUM	9480.000		9480.000		7760.000		1020.000		9890.000		988.000		3400.000	
MANGANESE	1920.000		1920.000		290.000		50.000		1170.000		18.000		165.000	
MERCURY	0.200	U	0.200	U	0.200	U	0.600		0.200	U	0.900		0.200	U
NICKEL	86.000		86.000		40.000		11.000	U	37.000		12.000		24.000	
POTASSIUM	4200.000		4200.000		2600.000		1300.000		3100.000		1200.000		2200.000	
SELENIUM	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U
SILVER	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
SODIUM	5130.000		5130.000		9380.000		1490.000		4000.000		1770.000		3060.000	
THALLIUM	7.000	U	7.000	U	7.000	U	7.000	U	70.000	U	7.000	U	7.000	U
VANADIUM	41.000		41.000		39.000		4.000	U	28.000		4.000	U	25.000	
ZINC	252.000		252.000		214.000		26.000		544.000		18.000		223.000	

EXPLANATION OF CODES:

J - ESTIMATED VALUE
B - COMPOUND FOUND IN BLANK
 - DETECTED AT CONCENTRATION SHOWN
U - UNDETECTED AT GIVEN INSTRUMENT DETECTION LIMIT
R - NOT REQUIRED FOR ANALYSIS
X - REJECTED VALUE
A - TICS ANALYZED FOR BUT NOT FOUND
 (TICS = TENTATIVELY IDENTIFIED COMPOUNDS)

301026

GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
INORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-03 DISSOLVED	MW-04 TOTAL	MW-04 DISSOLVED	MW-05 TOTAL	MW-05 DISSOLVED	MW-06 DISSOLVED	MW-06 TOTAL
ALUMINUM	100.000 U	3170.000	100.000 U	86400.000	100.000 U	100.000 U	15400.000
ANTIMONY	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U
ARSENIC	3.000 U	4.400	3.000 U	32.000	3.000 U	3.000 U	6.100
BARIUM	36.000	199.000	120.000	1010.000	75.000	38.000	150.000
BERYLLIUM	2.000 U	2.000 U	2.000 U	8.300	2.000	2.000 U	2.000 U
CADMIUM	5.000 U	5.000 U	5.000	29.000	5.000 U	5.000 U	7.100
CALCIUM	14700.000	14000.000	14000.000	14300.000	7180.000	25400.000	26900.000
CHROMIUM	4.000 U	6.800	4.000	36.000	4.000 U	4.000 U	19.000
COBALT	6.000 U	8.400	7.900	38.000	6.000 U	6.000 U	16.000
COPPER	9.000 U	23.000	9.000	157.000	9.000 U	12.000	44.000
IRON	100.000 U	8920.000	334.000	109000.000	238.000	100.000 U	37000.000
LEAD	1.000 U	6.800	1.000	48.000	1.000 U	10.000 U	16.000
CYANIDE	10.000 R	10.000 U	10.000 R	10.000 U	10.000 R	10.000 R	10.000 U
MAGNESIUM	3360.000	3260.000	2800.000	12000.000	2010.000	8370.000	10400.000
MANGANESE	14.000	1200.000	899.000	705.000	27.000	7.000 U	340.000
MERCURY	0.700	0.200 U	1.100	0.200 U	0.200	0.700	0.200 U
NICKEL	11.000 U	11.000 U	11.000 U	45.000	11.000	11.000 U	27.000
POTASSIUM	800.000	1900.000	2500.000	13000.000	17000.000	2500.000	2900.000
SELENIUM	2.000 U	2.000 U	2.000	2.000 U	2.000 U	2.400	2.000 U
SILVER	5.000 U	5.000 U	5.000	5.000 U	5.000 U	5.000 U	5.000 U
SODIUM	7770.000	5350.000	4250.000	5580.000	4160.000	73400.000	71200.000
THALLIUM	7.000 U	70.000 U	7.000	2.000 U	2.000 U	700.000	7.000 U
VANADIUM	4.000 U	6.500	4.000	146.000	40.000	4.000 U	79.000
ZINC	16.000	76.000	51.000	362.000	16.000	20.000	115.000

EXPLANATION OF CODES:

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GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
INORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-07D TOTAL	MW-07D DISSOLVED	MW-07S DISSOLVED	MW-07S TOTAL	MW-09 TOTAL	MW-09 DISSOLVED	MW-10-01 TOTAL
ALUMINUM	20700.000	100.000 U	100.000 U	20700.000	26200.000	100.000 U	19500.000
ANTIMONY	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U
ARSENIC	5.400	3.000 U	3.000 U	3.900	11.000	5.200	4.000
BARIUM	685.000	171.000	88.000	504.000	487.000	80.000	376.000
BERYLLIUM	4.600	2.000 U	2.000 U	3.200	3.300	2.000 U	5.600
CADMIUM	6.400	5.000 U	5.000 U	7.400	13.000	5.000 U	13.000
CALCIUM	38200.000	46900.000	7850.000	8160.000	5810.000	4290.000	92300.000
CHROMIUM	12.000	4.000 U	4.000 U	17.000	23.000	4.000 U	32.000
COBALT	16.000	7.300	6.000 U	17.000	10.000	6.000 U	883.000
COPPER	32.000	9.000 U	9.000 U	22.000	242.000	9.000 U	79.000
IRON	38400.000	100.000 U	100.000 U	39400.000	50200.000	115.000	38900.000
LEAD	23.000	1.000 U	10.000	36.000	30.000	1.000 U	10.000 U
CYANIDE	10.000 U	10.000 R	10.000 R	10.000 U	10.000 U	10.000 R	16.000
MAGNESIUM	15600.000	15700.000	1390.000	4640.000	3500.000	1540.000	47500.000
MANGANESE	350.000	72.000	14.000	239.000	252.000	10.000	31900.000
MERCURY	0.200 U	2.400	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U
NICKEL	29.000	11.000 U	11.000 U	21.000	22.000	11.000 U	11.000 U
POTASSIUM	4400.000	1400.000	7400.000	6500.000	2500.000	1800.000	9800.000
SELENIUM	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000
SILVER	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	6.800
SODIUM	10300.000	12000.000	17300.000	12900.000	11100.000	14200.000	507000.000
THALLIUM	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U
VANADIUM	43.000	4.000 U	4.000 U	46.000	103.000	4.000 U	30.000
ZINC	155.000	95.000	16.000	191.000	198.000	19.000	398.000

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GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
INORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-10-01 DISSOLVED	MW-10-02 TOTAL	MW-10-02 DISSOLVED	MW-11 DISSOLVED	MW-11 TOTAL	MW-12D TOTAL	MW-12D DISSOLVED
ALUMINUM	100.000 U	1910.000	100.000 U	100.000 U	73800.000	138.000	100.000 U
ANTIMONY	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U
ARSENIC	3.500	3.000 U	4.000	3.000 U	27.000	3.000 U	3.000 U
BARIUM	14.000	61.000	14.000	46.000	2840.000	5.000 U	5.000 U
BERYLLIUM	2.000 U	2.000	2.000 U	2.000 U	16.000	2.000 U	2.000 U
CADMIUM	5.000 U	5.000 U	5.000 U	5.000 U	34.000	5.000 U	5.000 U
CALCIUM	99300.000	93200.000	104000.000	5220.000	20900.000	17300.000	23600.000
CHROMIUM	12.000	13.000	13.000	4.000 U	29.000	4.000 U	4.000 U
COBALT	911.000	892.000	975.000	6.000 U	30.000	6.000 U	6.000 U
COPPER	9.000 U	45.000	9.000 U	9.000	56.000	29.000	9.000 U
IRON	2450.000	5750.000	2330.000	100.000 U	126000.000	5330.000	355.000
LEAD	10.000	10.000 U	1.000 U	1.000 U	40.000	5.700	1.000 U
CYANIDE	10.000 R	10.000 U	10.000 R	10.000 R	10.000 U	10.000 U	10.000 R
MAGNESIUM	51100.000	45800.000	52800.000	989.000	15900.000	6870.000	9110.000
MANGANESE	34100.000	32200.000	35500.000	7.000 U	1060.000	119.000	124.000
MERCURY	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U
NICKEL	11.000 U	11.000 U	11.000 U	11.000 U	59.000	11.000 U	11.000 U
POTASSIUM	13100.000	7600.000	12800.000	600.000	7900.000	800.000	700.000
SELENIUM	2.000 U	2.500	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U
SILVER	9.600	5.400	11.000	5.000 U	5.000 U	5.000 U	5.000 U
SODIUM	613000.000	510000.000	615000.000	1230.000	3170.000	8260.000	11000.000
THALLIUM	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U
VANADIUM	4.000 U	4.100	4.000 U	4.000 U	142.000	4.000 U	4.000 U
ZINC	105.000	723.000	124.000	14.000	586.000	128.000	13.000

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GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
INORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-12S TOTAL		MW-12S DISSOLVED		MW-13-01 DISSOLVED		MW-13-01 TOTAL		MW-13-02 DISSOLVED		MW-13-02 TOTAL		MW-14D TOTAL	
ALUMINUM	8700.000		100.000	U	100.000	U	100.000	U	100.000	U	100.000	U	346.000	
ANTIMONY	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U
ARSENIC	3.000	U	3.000	U	3.000	U	3.000	U	3.000	U	3.000	U	3.000	U
BARIUM	252.000		167.000		5.000	U	5.000	U	5.000	U	5.000	U	8.800	
BERYLLIUM	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U
CADMIUM	22.000		5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	16.000	
CALCIUM	8090.000		9150.000		44100.000		40800.000		44100.000		29100.000		56100.000	
CHROMIUM	8.100		4.000	U	4.000	U	4.000	U	4.000	U	4.000	U	4.200	
COBALT	9.600		6.000	U	6.000	U	6.000	U	6.000	U	6.000	U	12.000	
COPPER	31.000		9.000	U	9.000	U	14.000		9.000	U	21.000		20.000	
IRON	91200.000		353.000		773.000		899.000		882.000		1010.000		60200.000	
LEAD	14.000		1.000	U	1.000	U	2.300		1.000	U	1.500		21.000	
CYANIDE	10.000	U	10.000	R	10.000	R	10.000	U	10.000	R	10.000	U	10.000	U
MAGNESIUM	2870.000		2900.000		12700.000		12100.000		12900.000		11500.000		26700.000	
MANGANESE	312.000		53.000		187.000		180.000		184.000		176.000		508.000	
MERCURY	0.200	U	0.200	U	0.600		0.200	U	0.800		0.200	U	0.200	U
NICKEL	31.000		11.000	U	11.000	U	11.000	U	11.000	U	11.000	U	17.000	
POTASSIUM	2400.000		2400.000		800.000		600.000		700.000		600.000		1700.000	
SELENIUM	2.000	U	2.000	U	3.500		2.000	U	2.900		2.000	U	2.000	U
SILVER	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
SODIUM	8680.000		9020.000		14800.000		14200.000		14800.000		13300.000		20500.000	
THALLIUM	2.000	U	2.000	U	7.000	U	7.000	U	7.000	U	7.000	U	2.000	U
VANADIUM	26.000		4.000	U	4.000	U	4.000	U	4.000	U	4.000	U	4.000	U
ZINC	88.000		28.000		12.000		7.300		8.000		28.000		1840.000	

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GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
INORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-14D DISSOLVED	MW-14S DISSOLVED	MW-14S TOTAL	MW-16D DISSOLVED	MW-16D TOTAL	MW-16S TOTAL	MW-16S DISSOLVED
ALUMINUM	100.000 U	100.000 U	1840.000	100.000 U	100.000 U	32500.000	100.000 U
ANTIMONY	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U	17.000 U
ARSENIC	3.000 U	3.200	3.000 U	3.000 U	3.000 U	6.000	3.000 U
BARIUM	7.100	87.000	98.000	5.000 U	5.000 U	432.000	9.000
BERYLLIUM	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	6.500	2.000 U
CADMIUM	5.000 U	12.000	20.000	5.000 U	5.000 U	17.000	5.000 U
CALCIUM	69300.000	62300.000	53300.000	19800.000	16300.000	22500.000	19100.000
CHROMIUM	4.000 U	4.000 U	11.000	4.000 U	4.000 U	18.000	4.000 U
COBALT	8.700	11.000	11.000	6.000 U	6.000 U	25.000	6.000 U
COPPER	9.000 U	9.000 U	23.000	9.000 U	9.000 U	46.000	9.000 U
IRON	9060.000	50300.000	77600.000	100.000 U	1000.000	57700.000	100.000 U
LEAD	1.000 U	1.000 U	16.000	1.000 U	5.800	26.000	1.000 U
CYANIDE	10.000 R	10.000 R	10.000 U	10.000 R	10.000 U	10.000 U	10.000 R
MAGNESIUM	34300.000	22100.000	18200.000	8200.000	6710.000	10000.000	6580.000
MANGANESE	431.000	1390.000	1310.000	7.000 U	8.400	790.000	7.000 U
MERCURY	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U	0.200 U
NICKEL	11.000 U	11.000 U	28.000	11.000 U	11.000 U	27.000	11.000 U
POTASSIUM	1600.000	2900.000	2300.000	500.000 U	600.000	2900.000	500.000
SELENIUM	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U
SILVER	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U	5.000 U
SODIUM	25100.000	45100.000	37700.000	10300.000	8360.000	9940.000	10200.000
THALLIUM	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U	2.000 U
VANADIUM	4.000 U	4.000 U	8.100	4.000 U	4.000 U	79.000	4.000 U
ZINC	58.000	22.000	636.000	26.000	9.500	221.000	9.100

EXPLANATION OF CODES:

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GREENWOOD CHEMICAL SITE RI/FS
MONITORING WELL GROUNDWATER SAMPLES
INORGANIC ANALYSES
(UG/L)

SAMPLE ID	MW-14D DISSOLVED		MW-14S DISSOLVED		MW-14S TOTAL		MW-16D DISSOLVED		MW-16D TOTAL		MW-16S TOTAL		MW-16S DISSOLVED	
ALUMINUM	100.000	U	100.000	U	1840.000		100.000	U	100.000	U	32500.000		100.000	U
ANTIMONY	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U	17.000	U
ARSENIC	3.000	U	3.200		3.000	U	3.000	U	3.000	U	6.000		3.000	U
BARIUM	7.100		87.000		98.000		5.000	U	5.000	U	432.000		9.000	
BERYLLIUM	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	6.500		2.000	U
CADMIUM	5.000	U	12.000		20.000		5.000	U	5.000	U	17.000		5.000	U
CALCIUM	69300.000		62300.000		53300.000		19800.000		16300.000		22500.000		19100.000	
CHROMIUM	4.000	U	4.000	U	11.000		4.000	U	4.000	U	18.000		4.000	U
COBALT	8.700		11.000		11.000		6.000	U	6.000	U	25.000		6.000	U
COPPER	9.000	U	9.000	U	23.000		9.000	U	9.000	U	46.000		9.000	U
IRON	9060.000		50300.000		77600.000		100.000	U	1000.000		57700.000		100.000	U
LEAD	1.000	U	1.000	U	16.000		1.000	U	5.800		26.000		1.000	U
CYANIDE	10.000	R	10.000	R	10.000	U	10.000	R	10.000	U	10.000	U	10.000	R
MAGNESIUM	34300.000		22100.000		18200.000		8200.000		6710.000		10000.000		6580.000	
MANGANESE	431.000		1390.000		1310.000		7.000	U	8.400		790.000		7.000	U
MERCURY	0.200	U	0.200	U	0.200	U	0.200	U	0.200	U	0.200	U	0.200	U
NICKEL	11.000	U	11.000	U	28.000		11.000	U	11.000	U	27.000		11.000	U
POTASSIUM	1600.000		2900.000		2300.000		500.000	U	600.000		2900.000		500.000	
SELENIUM	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U
SILVER	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U	5.000	U
SODIUM	25100.000		45100.000		37700.000		10300.000		8360.000		9940.000		10200.000	
THALLIUM	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U	2.000	U
VANADIUM	4.000	U	4.000	U	8.100		4.000	U	4.000	U	79.000		4.000	U
ZINC	58.000		22.000		636.000		26.000		9.300		221.000		9.100	

EXPLANATION OF CODES:

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